Conclusion

The present results provide insight into understanding the mechanisms involved in movement praxis. Specifically, the use of a multidimensional error notation system, the analysis of intransitive limb gestures in the present research, and the use of transitive limb gestures in our previous work (Roy et al., in press), have identified the involvement of the right hemisphere in praxis.

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Are Text and Tune of Familiar Songs Separable by Brain Damage?

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The recognition of text and tune in songs was examined in a music-agnosic patient and five matched controls. Listeners had to focus on one component of the song at a time (text or music) and had to decide whether the component was familiar or unfamiliar. Songs were either matched (i.e., an original familiar or an original unfamiliar song) or mismatched (a combination of a familiar component with an unfamiliar one). Normal listeners displayed response patterns that are congruent with those obtained previously in different experimental settings and which showed that text and tune are difficult to separate. Data collected in the patient, however, suggest some independence between text and music in songs. Moreover, the usual asymmetry in favor of text was much reduced when later verses were used. Overall, the results are interpreted as revealing strong association, not integration, between the musical and the verbal component of familiar songs. © 2001 Academic Press

A song is an artful arrangement of text and music. In many ways, the text and the tune of a song are separable from one another. For one thing, music and speech rely on completely different notation systems. In practice, however, the text and the music of a song are tightly bonded as they are most often, if not always, heard and performed in a combined form. Studies of memory for newly learned songs have shown a particular relationship between the text and the tune of a song: Recognition of any component of a song (be it the text or the tune) is higher if the text and the tune are placed in their original combination, than when placed in a new arrangement or when played alone (Serafine, Crowder, & Repp, 1984; Serafine, Davidson, Crowder, & Repp,
170 TENNET XI

1986; Samson & Zatorre, 1991). This empirical result, termed the integration effect, has been interpreted as reflecting an integration between the text and the tune of a song. That is, the mental code for a song would not retain separate verbal and musical codes, but rather some unique, mixed, code.

Studies with brain-damaged populations have shown that amusic patients (i.e., patients who have difficulty processing music following brain insult) are able to make familiarity judgments when song texts are presented in a spoken form, while they are unable to do so when the tunes are sung on the syllable “la” (e.g., Peretz et al., 1994; Peretz, 1996; Griffiths et al., 1997). Thus, familiarity judgment on one component may be intact while it would be disrupted for the other component. These studies, however, have all assessed recognition of song components taken in isolation. The present study examined the recognition of song components in a brain-damaged patient when actual songs are presented.

We used a paradigm and materials different from the ones used in previous studies, which all involved novel songs in a recognition memory task imposing an important memory load on listeners (Serafine et al., 1984; 1986; Morrongiello & Roes, 1990; Samson & Zatorre, 1991; Crowder, Serafine, & Repp, 1990). For instance, the low recognition levels for tunes found in previous studies (sometimes at chance level, e.g., Serafine et al., 1984) indicate that the musical part of the songs did not enjoy a stable representation in the listeners’ memory and that songs were liable to interference. A familiarity-decision task was used here with songs that were highly familiar or completely unknown (matched songs) or resulting from the combination of one component of a familiar song with one component of an unfamiliar song (mismatched songs). Listeners had to focus their attention on one component of the songs at a time (the text or the tune) and had to decide whether this component was familiar or not.

We predicted that if text and tune are separable in memory, the recognizability of each component should not be influenced by the presence of the other component. Therefore, performance for matched tunes should be the same as for mismatched tunes. In contrast, if text and tune are integrated in memory, performance level should be higher for matched than for mismatched songs.

**Experiment 1**

**Method**

**Subjects.** C.N. is a 40-year-old, right-handed nurse who had bilateral temporal lesions 10 years prior to the investigation. C.N.’s performance on the French version of the Boston Diagnostic Aphasia Examination (BDAE, Goodglass & Kaplan, 1972) showed no evidence of aphasia. Her only complaint was music-related activities. The recognition of tunes that were once familiar to her was at chance level. The data as well as a thorough case history of the patient have been published elsewhere (Peretz et al., 1994).

**Matched controls:** Five women with no history of neurological or psychiatric disease served as C.N.’s controls. Like C.N., they were all nurses working in hospitals (mean age 39.6 years) without formal music education.

**Materials.** Ten pairs of song excerpts generated the 40 stimuli used in this experiment. Ten song excerpts were highly familiar and known to have been acquired in childhood (Peretz, Babaï, Lussier, Hébert, & Gagnon, 1995). Ten additional song excerpts were drawn from two collections of folk songs comparable in style to the familiar ones, but were unfamiliar (Berthier, 1979; Sabatier & Sabatier, 1987). Each unfamiliar song was selected so as to be interchangeable in text and tune with one familiar song. Care was taken to obtain the best fit in pause and accent locations between the musical parts and the text in the mismatched songs.
Each pair of excerpts generated four different types of songs: two matched songs, that is, a familiar and an unfamiliar song, and two mismatched songs, that is, a familiar text coupled with an unfamiliar tune, and a familiar tune coupled with an unfamiliar text. The procedure is shown in Fig. 1.

These 40 songs were sung by the first author without musical accompaniment and digitally recorded on a DAT Casio. Songs from the matched and mismatched sets were similar in length (means = 4.85 and 4.74 s for matched and mismatched songs, respectively, t(38) = 0.20, p > .05). These recordings were stored on the hard disk of a Macintosh IIFY and transmitted directly from the hard disk to the subject via a Digidesign Digital interface amplifier and Maico headphones. Two random orders were determined and the final products were presented to the subjects by using the Experimenter program (Altmann, Wathanasin, Birkett, & Russell, 1992).

Procedure. The same 40 songs served as stimuli in two conditions, which differed only by the instructions given to the subjects. In one condition, C.N., and her matched controls were instructed to judge whether the text of the songs was known or unknown while ignoring the tune (the "Text" condition). In the other condition, they were required to focus on tunes while ignoring the text (the "Tune" condition). Subjects were tested individually in a session lasting about 15 min. They had to respond as quickly and as accurately as possible, by pressing one of the two keys of a response box, depending on whether their response was "known" or "unknown." The subjects had 4 s to key in their response after the end of the trial, and the next trial began after a 2-s pause. No feedback was provided. C.N. and her matched controls received both instructions twice, thus amounting to four different sessions. For controls, the orders of presentation of the conditions were counterbalanced across subjects. C.N. received conditions following an ABBA design.

Pretests. Before the experimental sessions, C.N. and her matched controls were tested on two separate pretests to examine their performance when each component of the to-be-presented songs (i.e., the text and the music) was heard separately. In the first pretest, all familiar and unfamiliar songs which were to be used in Experiment 1 (n = 20) were sung on the syllable "la." In the second pretest, the text line corresponding to the text of each of these same familiar and unfamiliar songs was spoken by the same person. Subjects were asked to judge whether the tunes (pretest 1) and the text (pretest 2) were known or unknown. Results are shown in Table 1.

![FIG. 1. Example of the mismatching procedure used. A familiar song and an unfamiliar song generated two additional types of songs by mismatching the text of the familiar song with the tune of the unfamiliar song and by mismatching the tune of the familiar song with the text of the unfamiliar song.](image)
Results and Comments

The average proportion of hits (i.e., the proportion of ‘known’ responses when the component under focus is indeed familiar) and the proportion of false alarms (i.e., the proportion of known responses when the component under focus is unfamiliar) were calculated for the four types of songs, averaged across subjects and order of presentation\(^1\). The recognition score (proportions of hits minus the proportion of false alarms) for matched controls were entered in an ANOVA with Items as the random factor, taking Instructions (focus on Text/Tune) and Song type (Matched/Mismatched) as the within-items factors. Since C.N. was performing at chance level under the “Tune” instruction, obtaining 49 correct responses of 80 ($Z = 1.90, p > 0.05$ by a binomial test), her data in this condition were not examined further. Only her data in the “Text” condition, on which her performance was excellent (76/80), were so analyzed.

Table 1 displays the scores for Experiment 1 (left panel) for the two Instructions and the two Song types for C.N. and her matched controls.

For Matched controls, the effect of Song type was significant, with $F(1, 9) = 13.30, Mse = .40, p < .006$. The effect of Instruction was also significant, with better performance under the Text instruction than the Tune instruction, $F(1, 9) = 19.22, Mse = .45, p < .003$. The interaction between Instructions and Song type was also significant, $F(1, 9) = 6.64, Mse = .34, p < .031$.

Because of the very high performance levels in the Text condition, the difference between Matched and Mismatched songs just fell short of significance $t(9) = 2.24, p = .052$, whereas this difference was significant under the Tune instructions, $t(9) = 3.27, p < .05$, for paired $t$ tests. These results show that in normal subjects, it is very difficult to separate the text and the tune of a song. Even when a judgment of familiarity must be made on only one component of a song, the other component cannot be ignored and influences the judgment. A component of a song, be it the text or the tune, is easier to judge as being familiar or unfamiliar when it is accompanied with its original companion.

Overall, C.N. performed in the normal range for text recognition with an overall mean of .90 (range of controls .70–1.00). The advantage for Mismatched over Matched

\(^1\) A preliminary analysis revealed a test/retest effect in the data of C.N.’s matched controls. The second presentation yielded lower scores than the first order of presentation (proportions obtained were .90 and .83 for order 1 and 2, respectively). As this is more likely to be due to a fatigue effect than to a learning effect, the data were collapsed across the two orders.
songs was not significant, $t(9) = 0.43, p > .05$, for a paired $t$ test. Unlike normal listeners, however, C.N. could ignore the tune while she made a familiarity judgment on the text of a song. This lack of influence of the tune in C.N.'s judgments indicates that there is a fair level of separability between the text and the tune of a song.

Experiment 2

In Experiment 1, the lyrics of the song may be represented both in song memory and in “titles” memory since the first verse of the song often corresponds to its title (e.g., Frère Jacques). In order to test song memory, texts from later verses of the songs were considered here, but were sung on the same tune as in Experiment 1, hence allowing variance of the strength of the representation for words while keeping the tune constant.

Method

C.N. and her five controls participated in Experiment 2. The same 10 pairs of songs served for this experiment. Only, the text was changed so that it did not correspond to the first line of the songs, but was drawn from later verses. The only restrictions were that the text should not correspond to the tune title and the music should remain the same as in Experiment 1. The procedure was identical as in Experiment 1, except that subjects received each instruction only once.

Pretest. C.N. and her matched controls were again presented with a pretest to examine their performance when the text line of the songs was heard separately in a spoken form. Results are summarized in Table 1.

Results and Comments

The recognition scores were calculated in the same way as in Experiment 1. C.N. performed again at chance level under the “Tune” instruction, obtaining 23 correct responses of 40 ($Z = 0.79, p > .05$ by a binomial test), a finding consistent with that of Experiment 1 since the musical part of the songs in both experiments was the same. Table 1 displays the scores for Experiment 2 (right panel) for the two Instructions and the two Song types for C.N. and her matched controls.

In Matched controls, the effect of Song type was again highly significant, $F(1, 9) = 7.36, MSe = .020, p < .03$. Recognition of Text was still higher than Tune, but not statistically so, $F(1, 9) = 1.38, MSe = .05, p > .27$. The effect of Song type was found reliable under both instructions since the interaction between Song type and Instruction was not significant.

As for her matched controls, C.N. performed lower in this condition than in Experiment 1, but she performed within the normal range with an overall mean of .75 (range of controls .40–1.0). The effect of Song type was not significant, $t(9) = 1.0, p > .05$, for a paired $t$ test.

The results are consistent with the view that the text and the tune of a song are difficult to separate in normal subjects. Even when a judgment of familiarity must be made on only one component of a song, the other component cannot be ignored and influences the judgment. A component of a song, be it the text or the tune, is easier to judge as being familiar or unfamiliar when it is accompanied with its original companion. The usual superiority effect of the text over the tune can be lowered by using verses that are less familiar, without changing the advantage for original over nonoriginal songs.

In contrast with normals, C.N. could ignore the tune while she made a familiarity
judgment on the text of a song. The lack of influence of the tune in C.N.’s judgments indicates that there is a fair level of separability between the text and the tune of a song.

*General Discussion*

These two experiments both replicate and extend previous findings on the organization of text and tune in memory for songs. In support of past studies, we found that in a normal brain the text and the tune of songs are difficult to separate: It was easier to judge the familiarity of the text or the tune of a song when the song was original than when it was not. We showed here that this result is neither material or task bound, but rather holds across paradigms, language, and level of familiarity with the songs presented.

Our study also extends previous findings by showing that the usual superiority of text over tune can be lowered without affecting the ease of judging the components of matched over mismatched songs. In Experiment 2, we succeeded to make the text less recognizable than the corresponding tune, by selecting less familiar verses of the songs. In all previous studies (Serafine et al., 1984, 1986; Crowder et al., 1990; Morrongiello & Roes, 1990; Samson & Zatorre, 1991) as well as in our Experiment 1, the text was systematically better recognized than the accompanying tune. This systematic asymmetry in saliency for the text over the tune may account for a large part of the association effects observed previously. The fact that we could decrease the difference here without canceling the superior recognition performance exhibited for the tune sung with its original, but less salient, text demonstrates that the advantage of matched over mismatched songs does not simply rely on the text of songs. It is noteworthy, however, that across conditions, the tune contributes much less to the recognition of the text that the text contributes to the recognition of the tune. In the latter case, the text substantially aids tune recognition. This observation may be related to the functional role of music in verbal recall, as used in oral traditions. Typically, songs consist of many verses organized around a few melodic lines. The music serves as a sort of mnemonic for text recall (Gingold & Abravanel, 1987; Hyman & Rubin, 1990; Wallace, 1994; Peretz et al., 1995).

In normal listeners, it was easy to elicit behavior that is compatible with a view that suggests an integration between text and tune. The neuropsychological data, however, suggest that this relationship might be one of association, rather than integration. The data collected in our brain-damaged patient who had difficulty in processing the musical part of the songs suggest an association, not an integration, between the two components of a song. Our patient was able to decide whether the text of the songs was familiar or not, and her performance was not significantly influenced by the presence of the tune. If text and tune were integrated in memory, this familiarity decision should have suffered from the presence of an irrelevant tune. Yet, this pattern was not obtained, suggesting that text and tune are related by association links, each tapping on independent processing resources. These results converge with the existing neuropsychological literature that suggests separability between text and tune in memory recognition (Peretz et al., 1994; Peretz, 1996; Griffiths et al., 1997). It should be noted, however, that the opposite pattern of dissociation between text and tune in songs remains to be reported. That is, a patient with impaired processing of the verbal component of songs and intact processing of music, who would be able to judge the familiarity of the tune without any influence of the text, has, to our knowledge, never been described. Such a case, combined with C.N., would provide an instance of double dissociation and hence would provide stronger evidence for the autonomy of text and tune in songs.
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The Role of Nasals in Reading: A Normative Study in French

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Dual-route models of reading assume that reading can be done in two ways. A most common lexical route, on the one hand, allows regular and irregular words to be read while a second sublexical route allows nonwords and novel words to be read. A graphemic processing stage in sublexical reading is assumed to assemble the individual letters of a word or a nonword into multiletter graphemes prior to grapheme–phoneme conversion. The purpose of this study was to determine whether vowel/nasal clusters required as much time to be processed as