MELODIC-EXPECTATION RULES AS LEARNED HEURISTICS

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ABSTRACT

Evidence is presented that certain rules of melodic expectation are learned rather than innate. In an experiment, 28 trained musicians and 12 non-musicians were asked to predict the direction of controlled experimental melodies. Whereas the musicians' expectations fit two well-known rules, the rules were not evident in the expectancies of non-musicians. Moreover, the rules corresponded only approximately to melodic structure, suggesting the rough heuristics that people use to make predictions in other cognitive domains. In sum, the results suggest that musicians have learned imperfect but serviceable heuristics for making predictions in their area of expertise.

1. EXPECTATION RULES: LEARNED VS. INNATE

Musical expectations hold aesthetic interest because of their role in experiences such as suspense and surprise (Bissell, 1920; Meyer, 1956). They also hold perceptual and educational interest because of their role in facilitating musical skills: whether musicians are reading music, detecting tuning errors, or transcribing music by ear, they do so more quickly and accurately when the music conforms to their expectations (Anderson & Tunks, 1992; Bharucha & Stoekig, 1987; Sloboda, 1976; Unyk & Carlsen, 1987).

Expectations follow a number of psychological rules, some probably learned, others probably innate. An example of a learned rule is the expectation for common rather than unusual scale degrees (Schmuckler, 1989)—for example, diatonic rather than chromatic tones. Because scales vary across cultures, it seems likely that expectations based on scales are acquired through cultural exposure. By contrast, a quite possibly innate rule is pitch proximity, the expectation for small melodic pitch intervals (Carlsen, 1981). Pitch proximity relates to physical constraints on sound sources, and seems fundamental to our processing of pitched sounds, musical or otherwise (Bregman, 1990).

Other rules have a more ambiguous status: it is not clear whether they are innate or learned. These rules include the following:

1. *Skip reversal*[1]: the expectation that a melody will change direction after a large pitch interval (skip)—*e.g.*, that after an upward skip the melody will turn downward.
2. *Step momentum*[2]: the expectation that a melody will maintain its direction after a small pitch interval (step)—*e.g.*, that after an upward step the melody will continue upward.

A popular theoretical perspective holds that these two rules are innate—that they arise from fundamental laws of pattern perception, and that melodies are constructed to fit them (Narmour, 1990). In the present experiment, however, we find two pieces of contrary evidence:

1. We find that the rules are stronger in music students than in students without musical training. This suggests that skip reversal and step momentum are learned.
2. We find that the rules of expectation do not perfectly match the patterns in melodic structure. Instead, listeners' expectations predict melodies in a simplified and approximate way, much like the learned heuristics used in other domains of human prediction.

With respect to skip reversal and step momentum, the results suggest that melodies are not, in fact, constructed to fit innate expectations. Instead, expectations are learned to fit melodies.

2. EXPERIMENTAL DESIGN

2.1. Participants: musicians vs. non-musicians

28 music students and 12 non-music students were recruited to participate in the experiment. The median age for each group was 20. Music students participated to fulfill part of a course credit; non-music students were paid.

Whereas all of the musicians had between 5 and 20 years of music lessons and courses, none of the non-musicians had even one year. The difference in training between the musicians and non-musicians is one of the largest ever for a study of melodic expectation.

2.2. Task and response variables

In each experimental trial, students heard a melodic fragment and answered the following question: "If this melody were to continue, would it be more likely to go up or down." Students responded by pressing *u* or *d* on a computer keyboard. To encourage spontaneous responses, students were encouraged to respond as quickly as they could without guessing. Response times were also recorded.

[1] In various guises, this rule is known as "gap-fill", "pitch reversal," "registral direction," and "registral return" (Meyer, 1956; Narmour, 1990; Schellenberg, 1997).

[2] Also known as "process" or "good continuation" (Meyer, 1956; Narmour, 1990).

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2.3. Stimuli and manipulated variables

To control the effects of rhythm, the fragments were played in steady, unaccented quarter notes, each .75 seconds long (i.e., 80 notes per minute). To control the effects of tonality, each fragment consisted of a random ordering of the 12 pitch chromas (C, C#, etc.). The mean pitch of each melody was fixed just above middle C4, halfway between D4 and E*b*4, and the melody was fit into the narrowest possible range, subject to the constraints imposed by the manipulated variables.

Two variables were manipulated independently:

1. The interval between the last two notes varied from –11 to –1 semitones downward, and from +1 to +11 semitones upward.

2. The height of the last note varied from –4.5 semitones below the mean pitch to +4.5 semitones above the mean pitch.

The experiment used every combination of manipulated variables once, so that there were a total of 220 trials (11 interval sizes X 2 interval directions X 10 pitch heights). A new set of melodies and a new trial order was randomly generated for each subject.

3. RESULTS

3.1. Results for musicians

The results averaged across musicians are displayed in Figure 1.

The lower panel provides clear evidence for skip reversal. Following any downward skip (any interval from –3 to –11 semitones), musicians expected an upward continuation (i.e., reversal) more than 50% of the time. Likewise, after any *upward* skip, musicians expected a *downward* continuation more than 50% of the time. Skip reversal was stronger after large skips than after small ones; in addition, the response times after large skips were shorter, suggesting greater confidence.

The lower panel also provides evidence for step momentum. Following a downward step (–1 or –2 semitones), musicians expected a downward continuation more than 50% of the time. Likewise, after an upward step, musicians expected an upward continuation more than 50% of the time.

The upper panel, by contrast, suggests that pitch height had little effect on musicians' expectations. No matter how high or low the final pitch, musicians were almost equally divided between upward and downward expectations. If pitch height did affect expectations, the effect was too slight to be of substantive interest.

The effect of interval size was quite consistent across musicians. When logistic regression models were fit to individual musicians' responses, 25 of the 28 musicians displayed some tendency toward skip reversal, and 24 evidenced some tendency toward step momentum.

The effect of pitch height, by contrast, was inconsistent. 17 of the musicians fit the trend barely visible at the top of Figure 1—upward expectations when the melody is low, and downward expectations when it is high—but 10 musicians had the opposite tendency, and one had no tendency at all.

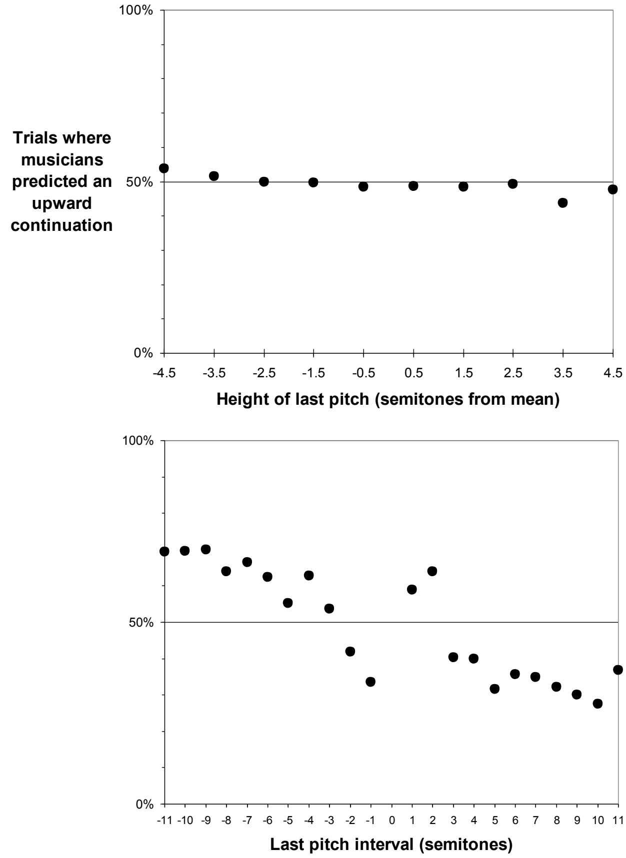

Figure 1. Results averaged across musicians.

3.2. Comparison with melodies

Contrary to the view that melodies are constructed to fit expectations, the patterns in the experimental results do not entirely match the patterns in melodies.

Pitch height and skip reversal. In melodies, pitch height is very useful for predicting melodic direction. From a high pitch, melodies tend to go downward; from a low pitch, they tend to go upward. The reason is range constraints: when a melody is near the extremes of its range, it has little choice but to retreat toward the middle—*i.e.*, regress toward the mean.

In many melodic repertoires, skip reversal is just an artifact of regression toward the mean. An upward skip usually lands on a high note, and from there the melody usually turns downward. So it is true that skips predict reversals—but only because skips provide information about pitch height. If accurate pitch-height information is available from another source, skips do not further aid prediction (von Hippel & Huron, 2000).

In short, an optimal strategy for predicting melodic direction would use pitch height and ignore skip reversal. Yet musicians did just the opposite: they relied on skip reveral and ignored pitch height.

The reason may be that skip reversal is a simpler strategy: it uses only the last two notes. By contrast, a strategy based on pitch height would require musicians to estimate the melody's mean pitch as a point of reference. To improve on skip reversal, this estimate would need to use more than two notes. Evidently, for music students, the increase in accuracy is not worth the trouble.

In short, in music, as in other domains, experienced persons rely on imperfect but serviceable prediction strategies (or heuristics) that minimize burdens on processing and memory. One such heuristic is skip reversal.

Step momentum and asymmetry. Step momentum may be another heuristic. In many melodies, step momentum is asymmetric—notably stronger after downward steps than after upward steps. Yet little asymmetry is evident in the experiment, where musicians expected step momentum after upward and downward steps alike. It seems that musicians have over-generalized from downward steps to upward steps—another example of a simplified prediction strategy.

3.3. Comparison with non-musicians

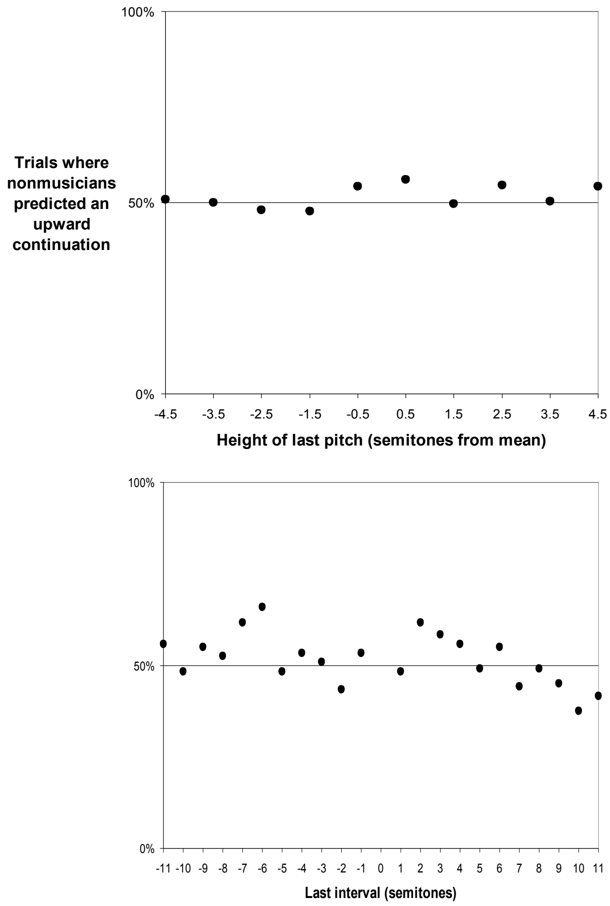

Figure 2: Results averaged across non-musicians.

The results for non-musicians are visibly different from those for musicians.

The averaged responses for non-musicians (Figure 2) are vaguely reminiscent of those for musicians (Figure 1), but the patterns for non-musicians are much less clear—and less consistent across subjects. When logistic regression models were fit to the responses of individual non-musicians, the slopes were significantly weaker than they were among the musicians. Just 8 of the 12 non-musicians displayed any tendency toward skip reversal, and only 7 of the non-musicians tilted toward step momentum.

If musicians and non-musicians used similar strategies, the musicians were far more systematic. Again, this suggests that skip reversal and step momentum are learned through engagement with music.

4. CONCLUSION

Contrary to a popular view, the results suggest that two well-known rules of melodic expectation are learned rather than innate. Both rules are stronger among musicians than among non-musicians. In addition, the rules only approximate musical structure. It seems that in music, as in other domains, experts have learned learn inexact but serviceable heuristics for making predictions in their area of expertise.

5. REFERENCES

1. Anderson, C.R., & Tunks, T.W. The influence of expectancy on harmonic expectation. *Psychomusicology*, Vol. 11, 1992, pp. 3-14.
2. Bharucha, J., & Stoekig, K. "Priming of chords: spreading activation or overlapping frequency spectra?" *Perception & Psychophysics*, Vol. 41, No. 6, 1987, pp. 519-524.
3. Carlsen, J. C. "Some factors which influence melodic expectancy." *Psychomusicology,* 1, 1981, pp. 12-29.
3. Meyer, L.B. *Emotion and Meaning in Music*. University of Chicago Press, 1956.
4. Narmour, E. *The Analysis and Cognition of Basic Melodic Structures: The Implication-Realization Model*. University of Chicago Press, 1990.
5. Schellenberg, E.G., "Simplifying the implication-realization model of melodic expectancy," *Music Perception*, Vol. 14, No. 3, 1997, pp. 295-318.
6. Schmuckler, M.A., "Expectation in music: investigation of melodic and harmonic processes," *Music Perception*, Vol. 7, No. 2, 1989, pp. 109-150.
7. Sloboda, J.A. "The effect of item position on the likelihood of identification by inference in prose reading and music reading," *Canadian Journal of Psychology*, Vol. 30, 1976, pp. 228-236.

8. Unyk, A.M., & Carlsen, J.C. "The influence of expectancy on melodic perception. *Psychomusicology,* 2, 1987, pp. 122-147.