Musical influences on the perception of time

by

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The rate at which time appears to pass is not uniform, but may vary depending on a number of factors. Time perception may be influenced both by the attentional state of the perceiver and by the characteristics of stimuli to which a person is attending (Fraisse, 1963; Ornstein, 1969). Several researchers have suggested that time perception is most generally related to the amount of processing activity (Michon, 1972; Ornstein, 1969). Others have attempted to develop a theory of time perception based on the concept of an internal clock (Kristofferson, 1980; Luce, 1972).

This paper concerns the perception of time during music listening. Although many studies of musical time have focussed on sensitivity to rhythm and meter (e.g., Longuet-Higgins & Lee, 1982), few have examined the ability of listeners to judge duration over several bars. In a study by Clarke and Krumhansl (1990), listeners were presented excerpts from pieces by Stockhausen (Experiment 3) and by Mozart (Experiment 6). The excerpts all differed in duration, but had an average duration of about 30 seconds. Listeners were asked to judge the duration of each excerpt, and were also asked to rate each excerpt on a number of subjective scales, such as complexity, variedness, and completeness. Regression analyses suggested that judgements of duration were highly veridical, and were apparently not influenced by the subjective characteristics of the excerpts.

Our investigation was an extension of the research reported by Clarke and Krumhansl (1990). For purposes of comparison, we used the same music used by Clarke and Krumhansl (1990, Experiment 6) -- Mozart's fantasie in C minor, K. 475. Our experimental method, however, differed from that used by Clarke and Krumhansl. First, listeners in our study were not asked to judge excerpts of differing durations. Thus, we removed that source of variation from duration judgements. Second, the listeners in our study were explicitly instructed to estimate *subjective* time, rather than veridical time. Third, each excerpt was presented at each of three tempi. Finally, both objective and subjective characteristics of excerpts were used as predictors of perceived duration. There were two parts to the study. In Part 1, listeners judged the duration of excerpts. In Part 2, other listeners provided subjective judgements of excerpts.

Method

Subjects. Sixteen musically-trained adult listeners participated in Part 1. Ten different trained listeners participated in Part 2. Listeners had a minimum of five years of musical training, and all reported normal hearing.

Musical materials. Eight musical excerpts from Mozart's fantasie in C minor, K. 475 were used. The starting locations of these excerpts were: bar 12, bar 28, bar 42, bar 84, bar 99, bar 135, bar 160, and bar 171. Each of the eight excerpts was presented at each of three tempi: slow, medium, and fast. The medium tempo for each excerpt was equal to the tempo markings indicated in the score. The fast tempo was 20 bpm faster than the medium tempo, and the slow tempo was 20 bpm slower than the medium tempo.

Apparatus. Musical excerpts were entered into an SE/30 Macintosh computer using Professional Composer software, and saved as MIDI files. MIDI files were then used with Experimental software created by A. McKinnell. The order of presentations was randomly and independently determined for each listener. Excerpts were output using the piano 1 timbre of the Roland U-20, and played through Sennheisser headphones.

Procedure. Part 1: First, a standard duration was established by presenting a black rectangle on the computer screen for 10 seconds. Listeners were instructed that, for each presentation, they would hear a drum sound shortly after the music started. Their task was to press any key on the Roland U-20 keyboard when a period of time had elapsed, beyond the drum sound, that was equivalent to the standard duration. The musical presentation stopped as soon as a response was made. Listeners were instructed to judge subjective time, rather than attempt to make veridical judgements. Practice trials were provided to help acquaint listeners with the task.

Part 2: Ten second excerpts were created from the excerpts used in Part 1. Listeners were presented these 10 sec excerpts, and rated them on five subjective qualities, using scales from 1-7. The qualities were: closure, information, varied, pleasing, and expectancy. Ratings of 7 for each quality indicated that the excerpt had closure, was high in information, was highly varied, was very pleasing, and ended with an implication that an important musical event was imminent. Practice trials were again provided.

Results and Discussion

For each presentation, the amount of time between the drum sound and each listener's key-press response was recorded. These values ranged from 6.39 seconds to 27.51 seconds, and averaged 13.03 seconds across all listeners and excerpts. A response 10 seconds after the drum sound would indicate veridical time perception. Thus, it is apparent that responses were nonveridical and that the musical excerpts generally had the effect of decreasing the perceived amount of time elapsed.

The 24 time values for the 16 listeners were then entered into an analysis of variance, with repeated measures on two factors -- Excerpt (eight levels) and Tempo (three levels). A significant main effect of Excerpt indicated that the perception of duration was dependent on the excerpt presented, $F(7, 105) = 4.59$, $p < .001$. There was no main effect of Tempo. However, a significant interaction between Excerpt and Tempo suggested that the judged duration of an excerpt was not always consistent across the three tempi, $F(14, 210) = 2.34$, $p < .01$.

Subjective ratings of excerpts

Mean ratings for the five sets of subjective ratings were then used as predictors of mean duration judgements in a regression analysis. For this analysis, we used data only from those listeners whose duration judgements on any trial were within two standard deviations of the mean. This procedure ensured that mean duration judgements were not distorted by data that reflected lapses in concentration. Using this elimination procedure, mean duration judgements were calculated from 10 listeners.

Correlations between mean duration judgements and mean ratings for subjective qualities were generally low -- the highest r values were associated with information ($r = -.35$) and pleasing ($r = -.38$). The negative correlations indicate that the greater the pleasingness and perceived amount of information, the sooner listeners thought the standard duration had elapsed. Using multiple regression, a reasonably good model of duration judgements included three predictors: information ($b = -.74$, $p < .05$), varied ($b = .68$, $p < .05$), and pleasing ($b = -.58$, $p = .08$), with a multiple $R = .65$, $p < .02$.

The relationship between information and perceived duration is compatible with Ornstein's (1969) storage-size hypothesis, if one assumes that information and complexity are similar constructs (Berlyne, 1971). Ornstein argues that the perceived duration of an event depends on the complexity of that event. Events that are high in complexity require more storage space in memory. This increase in storage requirement is thought to lengthen perceived duration.

It is notable that the relationship between information and pleasingness is thought to be nonlinear (Berlyne, 1971). Quite possibly, some of the subjective predictors also are nonlinearly related to judgements of duration. Thus, predictions of judged duration may be improved by considering nonlinear regression models.

Objective descriptions of excerpts

As a further analysis, 14 objective descriptions of each excerpt were obtained. The descriptions included: tempo, pitch dispersion (i.e., standard deviation), total number of notes, mean duration, mean pitch, number of key changes, and mean note density. Correlations between mean duration judgements and these objective descriptions were again generally low -- the highest r values were associated with pitch dispersion ($r = .49$), mean pitch ($r = -.35$) and mean note density ($r = .32$). Using multiple regression, a good model of duration judgements based on objective descriptions included two predictors: pitch dispersion ($b = .14$, $p < .01$) and mean note density ($b = .45$, $p < .05$). This model had a multiple $R = .63$, $p < .01$. This finding suggests that as pitch dispersion and note density increased, listeners waited longer before they responded that the standard duration had elapsed.

Finally, both mean subjective ratings and objective descriptions of excerpts were used in another multiple regression analysis. In this case, the most successful model included three predictors and had a multiple $R = .74$, $p < .001$. These predictors were: pitch dispersion ($b = .11$, $p < .01$), total number of notes ($b = .008$, $p < .05$) and perceived amount of information ($b = -.98$, $p < .005$). To simplify, the model suggests that a musical event will be perceived to be longer if the pitch dispersion is small, there are fewer notes, but the perceived amount of information is high. However, it is important to note that this model accounts for only 55% of the variance in duration judgements.

The perception of duration in music is not veridical, but is influenced by characteristics of the music. Factors such as the perceived amount of information and pitch dispersion appear to interact with the process of perceiving time. Although a complete understanding of these influences is not possible from the present analyses, the methodology used provides a useful alternative to that employed by Clarke and Krumhansl (1990). The process of unraveling the many possible influences on duration judgements presents a challenge for future research.

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