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INTERACTIVE EFFECTS OF MUSICAL AND VISUAL CUES ON TIME PERCEPTION: AN APPLICATION TO WAITING LINES IN BANKS [1]

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Summary.—This study explores the interactive effects of musical and visual cues on time perception in a specific situation, that of waiting in a bank. Videotapes are employed to simulate the situation; a 2 × 3 factorial design ($N = 427$) is used: 2 (high vs low) amounts of visual information and 2 (fast vs slow) levels of musical tempo in addition to a no-music condition. Two mediating variables are tested in the relation between the independent variables (musical and visual ones) and the dependent variable (perceived waiting time), mood and attention. Results of multivariate analysis of variance and a system of simultaneous equations show that musical cues and visual cues have no symmetrical effects: the musical tempo has a global (moderating) effect on the whole structure of the relations between dependent, independent, and mediating variables but has no direct influence on time perception. The visual cues affect time perception, the significance of which depends on musical tempo. Also, the "Resource Allocation Model of Time Estimation" predicts the attention-time relation better than Ornstein's "storage-size theory." Mood state serves as a substitute for time information with slow music, but its effects are cancelled with fast music.

Time has become a major component of satisfaction in the service sector (Hirshman, 1987): an increasing number of consumers perceive their discretionary time as more scarce and develop strategies to save time for activities other than mandatory ones (Berry, 1979). Consumers react emotionally and cognitively to the cost of time spent in service encounters (Haynes, 1990; Lovelock, 1990; Marmorstein, Grewal, & Fishe, 1992). However, public and private service institutions impose on their clients a psychological cost in addition to the economic cost: the cost of waiting time. In spite of its growing importance in our service economy, waiting time has not received the attention it deserves as a research topic (Feinberg & Smith, 1989).

Can the subjective waiting time be influenced by the perception of some specific stimuli? This study focuses on the influence of musical and visual stimuli on perceived waiting time. Hypotheses are proposed in which attention and mood mediate the relations affecting perceived time. We first review the literature on the respective effects of musical and visual cues on

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time and then suggest a global model integrating the hypotheses derived from this literature and based on a system of simultaneous equations.

Perception of Time from Musical Cues

As pointed out by Holbrook and Anand (1990), "music entails a wide range of elements . . . , ultimately taken into account. Nevertheless, some progress can be made by manipulation of one musical element at a time holding the rest constant" (p. 151). Our study focused on one of these musical elements, tempo, i.e., "musical speed" as defined by many authors (e.g., Holbrook & Anand, 1990, p. 151). Several researchers (e.g., Hevner, 1935; Brown, 1979; Budd, 1985) have identified tempo as the single most important factor in responses to music; more specifically, our study focused on the influence of musical tempo on temporal perception.

According to several theories (Fraisse, 1963, 1984; Zakay, 1989, in press) and some empirical studies (e.g., Hornik & Meir, 1990; Chebat & Filiatrault, 1993), perception of time is mediated by attention or mood. This literature review also examined the nature and significance of tempo on such key mediators.

Behavioral Effects of Tempo

Some studies show direct effect of slow-versus-fast music on time-related behavior. Clients' behavior at a restaurant is affected in two ways (Milliman, 1986). They complete their dinners more slowly (56 vs 45 min.) and wait longer for a table (47 vs 34 min.) under slow music conditions. Similarly, in another study (Milliman, 1982), clients' in-store traffic flow at a supermarket was slower under slow than under fast music, and clients bought more. Alpert and Alpert (1990) showed that "sad music" (which is slower, since their 'sad music' was methodologically defined by the authors as significantly slower than the "happy music") was more likely to be conducive of purchase intentions than 'happy music.'

Affective Effects of Tempo

Since Hevner (1937, p. 627) showed that "sadness is best expressed by . . . a slow tempo" and "sheer happiness . . . demands a faster tempo," many studies (in particular those reviewed by Bruner, 1990) explored the relation between musical tempo and mood. For instance, sedative music—which is slower, since it is defined as lacking "strong rhythmic and percussive elements" (Gaston, 1951, p. 43)—has been shown to decrease muscle tonus (Sears, 1957) and reduce anxiety (Jacobson, 1956). Conversely, stimulative music (which is characterized, among other things, as having a higher tempo) increased worry and emotionality (Smith & Morris, 1976, pp. 1192-

[2]Since Holbrook and Anand did not indicate the origin of their scales, it is difficult to under-

1193). Even more importantly, Holbrook and Anand (1990) showed that tempo (in fact, its logarithm) influenced linearly perceived activity and quadratically affect. These results confirm that musical tempo affects "arousal" and "pleasure" dimensions of mood.[2] Anand and Sternthal (1990) also found that verbal advertisements are better liked if a high tempo music was playing in the background than if simply read.

Attentional Effects of Tempo

Musical tempo also influenced attentional processes. Stratton and Zalanowski (1984, p. 23), who used the slower movements of some classical works (e.g., Mozart's Symphonies Nos. 40 and 41 or Haydn's String Quartet), perceived as "soothing" music by their subjects, and the faster movements of the same musical pieces, perceived as "stimulating" music, showed that the 'soothing' music, used as background music, "causes groups to talk more about an assigned topic" and thus "take more time" than the second type of music. The authors concluded that "'soothing' music helps focus attention on a task and ignore . . . distracting stimuli" (p. 23), whereas 'stimulating' music was likely to "attract attention on itself and thus away from the task" (p. 24). Also using music background, Madsen (1970, p. 315) showed that it is "detrimental to . . . the primary task" (i.e., focusing on reading). It should be stressed that their study did not contrast different types of music but only absence vs presence of music. Similarly, Anand and Sternthal (1990) showed that music has a significant distracting effect in the information processing of verbal advertisement.

Since slower music enhanced subjects' attention (e.g., Stratton & Zalanowski, 1984), subjects were hypothesized to be more attentive to temporal cues. The most obvious source of such cues are those of the music itself since, as Macar (1980, p. 223) put it in her most remarkable synthesis of studies on "Time Psychology," there is an "intimate relationship between perception of rhythm and perception of time duration" [translated from French]. Paradoxically, however, the direct effects of musical tempo on time estimation have not been investigated often. In our literature search, we found only one study on that topic (Bickel, 1984). The conclusions were that musical tempo is more than a regular sequence of auditory cues, such as those of a metronome, and that music is not a reliable source for subjective assessment of time duration.

Effects of Visual Cues on Time Perception

Studies on the relation between visual cues and temporal perception are paradoxically more scarce than those on musical cues. These studies focus on

stand exactly the concepts used; however, their set of adjectives is very similar to the Mehrabian-Russell mood scale which is tridimensional, pleasure-arousal-dominance. Holbrook and Anand, however, do not seem to have used the "dominance" concept.

the effects of amount of information contained in visual cues. In a significant study, Predebon (1988) showed the effects of visual information. Subjects were exposed to one of three figures (1 unambiguous, 1 ambiguous, or 2 alternating unambiguous) during the same objective time (40 sec.) and had to estimate the duration of the inspection period. The "alternating unambiguous figure" condition produced longer time judgments, but there was no significant difference in temporal judgment between ambiguous and unambiguous figures.

Another study on visual information processing (Stelmach & Herdman, 1991) focused on the speed of information transmission in the visual system. Subjects judged the temporal order of two visual stimuli while directing their attention toward one of the stimuli or away from both stimuli. Directed attention was shown to play a key role in the perception of temporal order. Given equal onset times, the attended stimulus appeared to occur before the unattended stimulus. The authors interpreted the results in the following way, that attention affects the speed of transmission of information in the visual system. It may be gathered from the results of these two studies that, for a given quantity of information received in the same objective time, if no other cues are available (for instance, auditory cues), attention to visual cues reduces the perceived time. These results confirmed the "attentional models" of time perception, the basic prediction of which is that there is a "negative relationship between information-processing load required during a target interval and its subjective duration" (Zakay, in press).

Auditory vs Visual Cues for Assessing Time Intervals

Most studies relating time perception to auditory or visual cues focus only on one of the cues; however, we are almost constantly exposed to both kinds of cues and make temporal judgments based on competitive cues from these two sources. Few studies partially fill the gap; they focused on the differential effects of visual and auditory cues, not on their combined effects. They showed, however, some striking differences in the perceptual processes of both kinds of cues. In Meredith and Wilsoncroft's research (1989), subjects were exposed to computer monitors that presented equally long intervals of time bounded by either a visual cursor or by auditory tones. Auditorily bounded intervals were judged longer than visually bounded intervals. Two studies compared the accuracy of temporal coding by either auditory or visual cues. In both cases, auditory cues proved to be superior. In Schab and Crowder's study (1989), subjects were presented lists of items separated by different interstimulus intervals that were either empty or filled with either auditory or visual nonverbal signals. When judging the length of the interval, subjects were more sensitive to auditory than to visual signals. In Glenberg, Mann, Altman, and Forman's experiment (1989), subjects had to reproduce a rhythmic sequence of short vs long auditory stimuli or short vs long visual stimuli. Results showed that accuracy in the reproduction of auditory rhythms was superior to that of visual rhythms.

The fact that auditory cues, however, provide the subjects with more accurate temporal estimates does not mean that auditory cues necessarily prevail over visual cues. In audiovisual perceptual conflicts, subjects have been shown to give priority to visual stimuli (Witkin, Wapner, & Leventhal, 1952; Howard & Templeton, 1966; Vurpillot, 1967). In proprioceptive conflicts with visual stimulation subjects adapt their proprioceptive perception in such a way that they adjust their perceptions with visual information (Delorme, 1982). Some tentative models (Julesz & Hirsh, 1972; Kubovy, 1981), conceptualizing similarity among the perceptual attributes of vision and audition (regarded inherently as both temporal and spatial), raised a heated controversy (Handel, 1988; Kubovy, 1988). These models hardly can be the base for elaborating our own hypotheses.

Hypotheses

Two sets of hypotheses are directly derived from the reviewed differential effects of visual vs musical cues: one set is related to their effects on attention, the other is related to their effects on mood, i.e., the two mediators of our model.

Hypotheses related to attentional processes.—In the presence of slow music, the attentional process is enhanced; consequently, attention to specific visual cues is also enhanced.

Following the 'attentional models'[3] (Frankenhauser, 1959; Priestley, 1968; Hicks, Miller, & Kinsbourne, 1976; Zakay, 1989), we hypothesized a negative relation between the level of attention and time perception. Since the amount of attention is limited and since our experiment takes place in a context of retrospective time estimation, the more attention is devoted to the observation of the environment, the less attention is devoted to the cognitive timer. More precisely, following Zakay's (in press) Resource Allocation Model of Time Estimation "in a retrospective context of time judgment (i.e., when subjects are asked to assess time duration of an event, after the event ended), priority of attentional resources allocation is given to processor of information" and not to the time processor. Some empirical studies have confirmed this view (e.g., Thomas & Cantor, 1978; Brown, 1985).

Following the attentional model's prediction, it was hypothesized that the more visual stimuli, the more visual information is likely to be attended and stored and, consequently, the shorter is the perceived time.

Hypotheses related to mood.—In the presence of slow music, low mood

[3]This hypothesis implicitly rejects Ornstein's (1969) storage-size model which has been disconfirmed recently in several studies (e.g., Hawkins & Tedford, 1976; Hanley & Morris, 1982) and which predicts a positive relation.

is more likely than high mood (e.g., Holbrook & Anand, 1990); then, following Schwarz and Bless (1991), it was proposed that lower mood triggers information-processing strategies oriented toward more visual details. Consequently, it was hypothesized that, in the presence of slow music and in a retrospective context, lower mood reinforces the relation expected from the attention models, that is, the more attention to visual cues, the shorter perceived time.

It was hypothesized that low visual stimulation produces a low mood [in particular a low level of 'arousal,' the second factor in the three-factor Mehrabian-Russell scale of emotions (Mehrabian & Russell, 1974)].

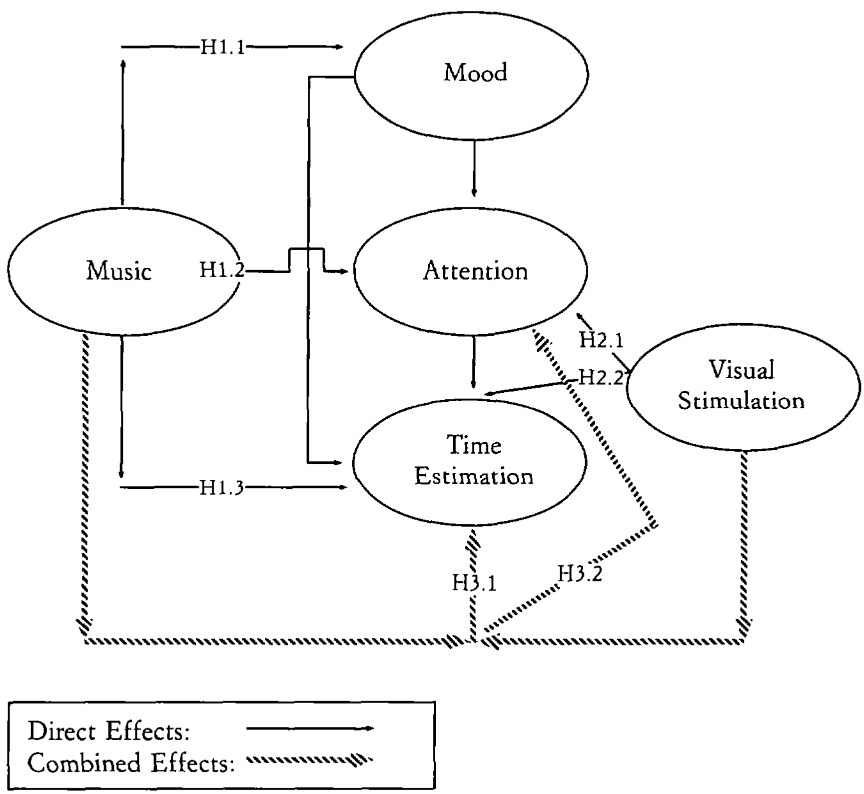

FIG. 1. Hypotheses tested through multivariate analysis of variance

The following hypotheses were proposed:

H1—Main effects of slow (vs fast) music

H1.1 Mood is lower.
H1.2 Visual attention is enhanced.

H2—Main effects of low (vs high) visual stimulation
H2.1 Attention is enhanced under high visual stimulation.[4]
H2.2 Time is perceived as shorter under high visual stimulation.

H3—Combined effects of music and visual stimulation[5]
H3.1 Time is felt as shortest when high visual stimulation and slow music are combined.
H3.2 Attention is highest when high visual stimulation and slow music are combined.

H4—Effects of mood and attention on time estimation
H4.1 Time is perceived as longer under lower mood.
H4.2 Time is perceived as shorter when attention is higher.

Fig. 1 shows the configuration of our hypotheses.

METHOD

Independent Variables

Two independent variables were manipulated, visual stimulation and musical tempo, in a 2 × 3 factorial design (low vs high visual stimulation and slow musical tempo vs fast musical tempo vs no music).

Videotapes.—The basic methodological tool was a set of videotapes. The methodological decision to use videotapes is justified below. Our videotapes were filmed by a professional team of film-makers who were instructed to maintain the same decor, zooming, and light intensity in all experimental conditions. The two interacting characters (the employee and the client) were professional actors who were instructed to behave identically in all conditions. The tapes show a waiting line in a real bank branch. At the counter a client is speaking to the teller loud enough to be heard clearly by the subjects of the experiment. After the usual daily greetings, the client indicates which financial operations he wants. There are three operations and the employee does the transactions. All videotapes last 4 min. and 6 sec.

Subjects were instructed to imagine that they are waiting in line and that the camera's picture is what their eyes would really see in the line. They were also instructed to imagine that they are the next clients to be served right after the client they see being served at the counter.

The ecological validity of such a method is supported by several studies. In a study by Carpman, Grant, and Simmons (1985), a videotape was produced to present an architectural model of hospital premises where a new

[4]No hypothesis relates visual stimulation and mood since no study was found to document this relation.
[5]No hypothesis relates the combined effects of visual stimulation and music on mood because no previous study documented this relation.

entrance of the parking deck of the hospital should be built. In this study, respondents could imagine themselves driving toward the parking deck and could answer questions about its adaptation to the needs of the hospital patients and visitors. Bosselman and Craik (1987) have reported substantial congruence between direct and simulated presentations in the studies they reviewed. Hershberger and Cass (1974) compared the ecological validity of different representative media (videotapes, slides, films) with direct presentation of real housing: each of the respondent groups was asked to evaluate the same housing examples; their results showed that the ratings obtained from the real environmental group and the simulation groups were highly correlated (from .72 to .79).

A recent study by Bateson and Hui (1992) is even more relevant to assess the ecological validity of videotapes in environmental psychology. They showed that videotapes and slides can be used not only to evaluate the reactions to simulated environmental settings but also for testing theories. These two researchers had previously developed a model of the effects on perceived crowding in a service setting (a London train station) on emotional reactions and "approach-avoidance" of potential customers. Their model was tested in three different experimental procedures: in the field, through slide simulation, and through videotapes. The three correlation matrices obtained from these three procedures were compared through Lisrel analyses: "The analysis produced" statistical results "showing that the hypothesis that three correlation matrices are equal could not be rejected" (p. 278). Their results led them to "claim that the findings from using slides and videotapes have both internal and external validity, at least in this study" and that "the large number of benefits that come from laboratory studies can thus be gained without apparently jeopardizing external generalizability" (p. 279).

The employment of videos allowed us to make sure that all cues are identical for respondents exposed to one given experimental condition, *viz.*, objective waiting time (4 min. and 6 sec.), visual stimuli, musical stimuli, and the employee's behavior. This point is particularly important in studies related to services. The "high people content," as Bateson and Hui (1992, p. 271) stated, including both service personnel and consumers, introduces much uncertainty. Both the variability in mood of all parties and the frailty of operating systems compound this problem. In particular, in this study, the employment of videos allowed us control so visual stimuli were exactly the same for all respondents in the same experimental condition: in a field study it would have been virtually impossible to control that every subject had been exposed to the same variety of visual cues or had been waiting in line for exactly the same duration. Havlena and Holbrook (1986, p. 396) suggested that there are two additional advantages of using "hypothetical consumers" (that is, the client at the counter shown on the videotape), "(a) to provide a projective task and thereby to discourage social effects and (b) to avoid problems involving differences in reactions to specific types of activities."

Musical manipulation.—Two excerpts from Mozart's Symphony No. 41 were chosen, a 4-min. and 6-sec. excerpt from the second (slow: "Andante Cantabile") movement and a 4-min. and 6-sec. excerpt from the fourth (fast: "Molto Allegro") movement. The justification for this choice was twofold. (1) The fact of choosing the same symphony allowed us to control the musical atmosphere. Had we chosen two different works of Mozart, two works of two different composers (say, Mozart and Brahms), or two works reflecting two different cultures (say, classical and pop music), that could not have been achieved. (2) Choosing the same symphony allowed us to control familiarity, which was shown to influence liking (e.g., Bradley, 1971; McSweeney & Bierley, 1984), arousal (Fontaine & Schwalm, 1979) and, even more importantly, perceived duration (Kowal, 1987). It was also decided to avoid symphony openings, which are generally better known than the rest of the symphony.

In addition to these justifications, the musical work we chose had already been tested in a psychomusical experiment. Stratton and Zalanowski (1984) tested the slow vs fast movements of some classical works and found that the slow movements were perceived by their subjects as more soothing and the fast movement as more stimulating. They found a "100% consensus on the labels for these selections" in a 25-individual control group. Such a remarkable result encouraged us to use three symphonies these authors mentioned in their work[6] in a pretest. A group of 30 management students were used to test the degree to which each of the six musical pieces (3 symphonies × 2 movements), each of them lasting 5 min., was perceived as familiar vs unfamiliar, liked vs not liked, fast vs slow. Each of the scales was a bipolar 6-point scale: the decision to have an even number of points on the scale was made to force subjects to choose between the two poles. All six pieces scored almost identically in terms of familiarity (from 2—"very unfamiliar" to 3—"unfamiliar"). In terms of liking, Mozart's symphonies Nos. 40 and 41 (with a slight nonsignificant advantage for No. 41) scored higher than Haydn's Surprise Symphony, and more importantly, for each of the three symphonies, the fast movement scored not significantly higher than the slow

[6]We eliminated from our study Haydn's String Quartet; the second movement of this musical work is shown to have a 'soothing' effect; however, the authors do not mention a 'stimulating' counterpart. Had we chosen this string quartet, we would have had to use another work in the 'fast tempo' condition, which would have cancelled the two positive implications of using the same work, *viz.*, control of musical atmosphere and familiarity. The same remark applies to 'Mozart's Piano Concerto, Third Movement,' shown as 'stimulating' but without a 'soothing' counterpart (in addition to the fact that we do not know which of the 27 Mozart Piano Concertos was tested here!).

movement [except that, in the case of Haydn's Surprise Symphony, the *t* test was almost significant ($t_{29} = 1.52$, $p = .08$)]. The tempo did not affect liking for the two Mozart symphonies in particular. In terms of tempo, the fast movements of the three symphonies were scored significantly faster than the respective counterparts.

For several reasons, Mozart's Symphony No. 41 was finally selected. Over-all, it was (slightly) better liked than Symphony No. 40 and significantly better liked than Haydn's Surprise Symphony. We decided to use the most liked symphony in order not to irritate our subjects. Background music is not intended to irritate and irritation could enhance the distractive effects of music.

In addition to the choice of the musical work, the musical interpretation had to be chosen. Moles (1971) showed the wide variation of speed in the interpretation of classical musical works by different orchestra conductors and its influence on information processing. Holbrook and Anand (1990) stressed the importance of the "tempo giusto": "performances that depart from this 'tempo giusto' would be perceived as too slow and disvalued accordingly" (p. 152). Some colleagues, experts in music, suggested that the standard interpretation, against which other interpretations are assessed, is that by Karl Bohm. This "standard" of Karl Bohm's interpretation was used (Karl Bohm and the Wiener Philharmoniker Orkestra, recording by Deutsche Gramophon).

The two movements were recorded and played as background music on the videotapes at the same intensity, considered comfortable to listeners having normal hearing threshold. Music intensity had to be controlled since it affects arousal with normal auditory acuity (Duffy, 1951) and customers' behavior (Smith & Curnow, 1966).

Visual manipulation.—Two levels of visual stimulation were used. The lower level was a fixed plan showing the employee-customer interaction without any movement of the camera, and without any appearance of any other client or another employee on the screen. The high visual stimulation consisted of moving the camera toward several points of interest in the bank, other clients, other employees working at the counter, printed advertisements, posters and paintings on the walls, closed-circuit TV advertisements, etc. To test the informational content of the two levels of visual information, the group used to test the musical manipulation was split in two subgroups of 15 individuals each, each subgroup being exposed to one of the two levels of visual stimulation. A short questionnaire was administered after they were exposed to each of the videotapes; the "high level" videotape scored significantly higher on the following (6-point) scales. "Having watched the videos, I know (very little, very much) about (a) how clients are serviced in this branch; (b) how their employees work; (c) the working atmosphere." The videotape of high visual stimulation carried more visual information than the low level counterpart. The two videotapes were not only different in terms of informational content but very likely also in terms of the pleasure to watch. In other words, it is very likely than an affective bias had been introduced when manipulating the informational content; however, we doubt that it could have been avoided: low stimulation is inherently related to low affect.

The 'high-level' videotape also was rated higher on interest and the technical quality (6-point) scales.

Dependent Variables

Attention level.—Subjects were asked to list all physical elements or thoughts they had in relation to a specific perceptual domain: the quality of services in this bank. Subjects may have noticed some physical items or may have elaborated thoughts: only those listed in the SERVQUAL scale (Parasuraman, Zeithalm, & Berry, 1985, 1991) were accepted as relevant, because their scale is derived from a comprehensive and widely accepted model of consumers' perceptual processes based on several dimensions related to the quality of services. This scale is based on the assessment of 26 items (e.g., physical appearance of personnel, equipment, length of delivery process, service reliability) and was used by us to create a preconceived repertory of items related to service quality.

In this repertory, the items that our subjects had noticed were classified in three categories: "explicit elements," "logical deductions," and "nonlogical deductions." 'Explicit elements' refer to what things, individuals, or situations subjects have seen on the videotape, namely, technical equipment, decor, employees' physical appearance. 'Logical deductions' is a reference to a generalization of or a direct causal attribution about what they saw, employees' courteousness, and their attitudes. 'Nonlogical deductions' refer to abstract deduction, especially at the level of the financial institutions: banks' reliability, banks' personalized services and commercial policy.

The three-level classification allowed assessment of the cognitive activity of subjects: the more deductions subjects make, the more connections they make with available knowledge and the more active is the "Information Processor." This classification may allow us to distinguish between mere memorization of plain facts and more personalized elaborations. It was presumed that the deeper the cognitive activity, the stronger the effect on time estimation.

Subjects were asked to record all elements of the videotape they could remember or think of. Two graduate students were asked to review the subjects' records and classify the elements recorded in one of the three categories. Three scales were used; the 'explicit' scale was the number of factual elements memorized by subjects, the 'logical' scale was the number of logical deductions made by subjects, and the 'nonlogical' scale was the number of nonlogical deductions made by subjects.

Mood.—The mood scale used was the Mehrabian and Russell (1974) mood scale. This scale is widely used and highly reliable Cronbach alphas of .91, .81, and .68, respectively, for the three dimensions of mood, pleasure, arousal, and submissiveness, were reported by Russell, Ward, and Pratt (1981). These authors obtained three factors through a principal components analysis; together the factors accounted for 47.7% of the total variance.

In the present study, our own principal components analysis (SPSS package) based on completed questionnaires showed not three but four factors. The first was clearly identified with 'pleasure' and accounted for 32.5% of total variance (eigenvalue = 3.90); the second, which comprised the 'arousal variables' only, explained 18.2% of variance (eigenvalue = 2.18); the third, which accounted for 14% of the variance, reflected the 'dominance concept' (eigenvalue = 1.68). The fourth was loaded by only one variable, "sleepy vs awake" and explained 9% of total variance. This variable belonged to the 'arousal' concept (eigenvalue = 1.09). We used only the first three factors in our own analysis.

Time estimation.—After being exposed to the waiting-line videotape, subjects were asked to estimate how long it lasted. The question was straightforward: "How much time elapsed since the moment you entered the line (beginning of the videotape) till the moment you were able to reach the counter (end of videotape)?" [The end of the waiting time was signaled by the following cues: client leaving the counter and the announcement from the employee who said "Next, please!".] Subjects were requested to answer in "number of minutes" and "number of seconds."

Subjects.—Each of the 427 undergraduate students, following the same basic management course in our university, was randomly assigned to one (and only one) of the six experimental conditions. All cells contained approximately the same number of subjects; 228 were women students. Ages varied from 21 to 40 years (average age = 24); 391 cases were accepted; 36 were rejected as data were missing.

Results

Internal Validity

Cronbach alphas were computed for each of the scales we used. The coefficients alpha for the three dimensions of the Mehrabian-Russell mood scale (1974) are .81 for 'pleasure,' .80 for 'arousal,' and .68 for 'dominance.'

Testing Hypotheses Related to Independent Variables

A multivariate analysis of variance from the SPSS package (Norušis, 1991) was performed, the independent variables of which were 'musical tempo' (three levels: no music vs slow vs fast music) and 'visual stimulation' (two levels: low vs high). The analysis allowed us to test three hypotheses, H1, H2, and H3, stated above.

Main effects of music (H1).—(H1.1) Music had no effect on any of the three mood factors, so H1.1 is rejected. Also, (H1.2) none of the three dimensions of attention was significantly influenced by music, so H1.2 is rejected. Note that time was not felt as significantly longer under any one of the three musical conditions. In short, H1 is rejected.

Main effects of visual stimulation (H2).—(H2.1) None of the three dimensions of attention was affected significantly by the low vs high visual stimulation. H2.1 is rejected. (H2.2) Time was perceived significantly longer ($F_{1,385} = 8.81$, $p = .003$) under high than under low visual stimulation (368 vs 330 sec.). The hypothesis (H2.2) predicted, however, the opposite direction. In addition, for hypothesized relations, the multivariate analysis of variance showed that one dimension of mood, *viz.*, 'pleasure,' was also significantly affected by the amount of visual stimulation ($F_{1,385} = 3.92$, $p = .05$): 'pleasure' was higher under high than under low visual stimulation.

Combined effects of music and visual stimulation (H3).—The combined effects of music and visual stimulation on mood were not significant on any of the three dimensions of mood, i.e., pleasure, arousal, and dominance. (H3.1) Time perception was significantly ($F_{2,385} = 3.12$, $p = .05$) affected by the combined effects of music and visual stimulation (H3.1); see Fig. 2. Results show different effects of music under high vs low visual stimulation. Whereas under low visual stimulation the effects of music on time estimates were monotonic and positive, under high visual stimulation they were quadratic ($F = 4.5$, $p = .03$). Under fast music, low vs high visual stimulation had no significant effects on time estimates (335 vs 327 sec.), whereas under slow music it had significant effects (330 vs 403 sec.).

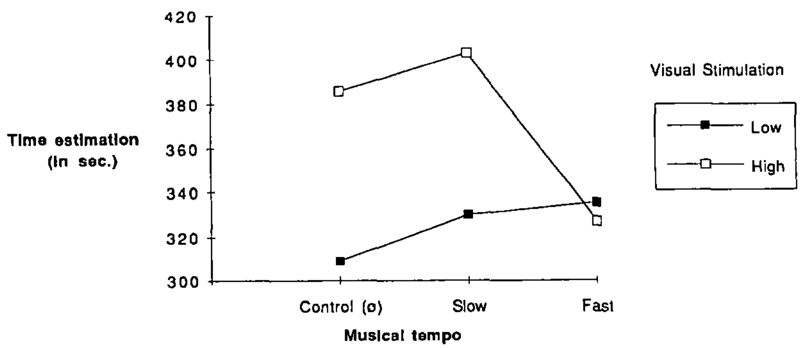

FIG. 2. Combined effects of musical tempo and visual stimulation on time estimates

One dimension of attention, i.e., 'nonlogical,' was significantly ($F_{2,385}$ = 4.39, p = .01) affected by the combined effects of visual and musical stimuli (H3.2). The other two dimensions were only marginally affected (for 'recall of factual elements' $F_{2,385}$ = 2.31, p = .15; for 'logical deductions' $F_{2,385}$ = 2.15, p = .12). Fig. 3 shows the relationship for the 'nonlogical' dimension.

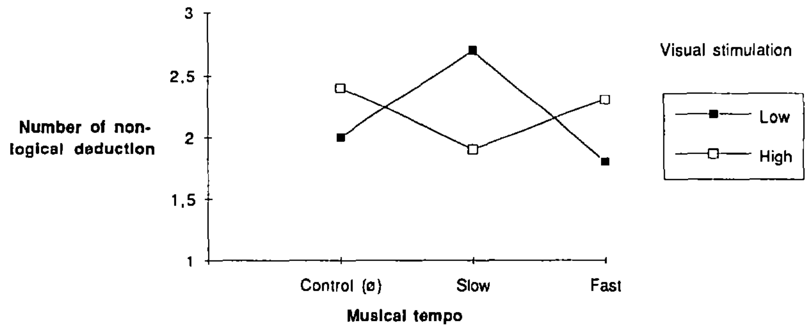

FIG. 3. Combined effects of musical tempo and visual stimulation on nonlogical deductions

Under both low and high visual stimulation, the relations were quadratic (F = 4.48, p = .03 for the weighted quadratic term in the case of 'low' visual stimulation and F = 4.56, p = .08 for the 'high' condition) but the 'high visual stimulation' curve is V-shaped, whereas the 'low visual stimulation' curve is an inverted V shape. Slow music had two opposite effects: it either enhanced the number of nonlogical deductions (2.7 under low visual stimulation) or reduced it (1.9 under high visual stimulation).

Testing the Hypotheses H4.1 and H4.2 Related to Effects of Mood and Attention on Time

To assess the effects of the two mediating variables, i.e., mood and attention, on time estimates, a series of structural equations were tested in the EQS (Bentler & Chou, 1990) program of the BMDP, Version 3.00(C), statistical package by Bentler (1989). The EQS models were built upon the multivariate analysis of variance. These results showed that music had no direct one-way effect on the dependent or mediating variables but it did have a significant effect when combined with visual stimulation. Also, visual attention directly affected several of these variables. Consequently, we first tested the hypothesis that the level of music affected the very structure of the relations between visual stimulation, the two mediators, and the dependent variables. The structural equations system is depicted in Table 1; the basic structure is shown in Fig. 4.

To test this model under the three music conditions (i.e., no, slow, fast), we imposed a constraint (C_1), that is, the relation between visual

TABLE 1
STRUCTURAL EQUATIONS FOR WAITING TIME MODEL

Pleasure	$V_2 = a_2 \cdot F_1 + D_1 \cdot E_1$
Arousal	$V_3 = a_3 \cdot F_1 + D_2 \cdot E_2$
Submissiveness	$V_4 = a_4 \cdot F_1 + D_3 \cdot E_3$
Explicit	$V_5 = a_5 \cdot F_2 + D_4 \cdot E_4$
Logical	$V_6 = a_6 \cdot F_2 + D_5 \cdot E_5$
Nonlogical	$V_7 = a_7 \cdot F_2 + D_6 \cdot E_6$
Mood	$F_2 = a_8 \cdot F_1 + agV_1 + D_7 \cdot E_7$
Time Estimation	$V_8 = a_9 \cdot F_2 + a_{11}F_1 + a_{12}V_1 + D_8 \cdot E_8$

Note.—F_1 = attention and V_1 = visual stimulation.

stimulation and time estimation. The purpose of such a constraint is to verify the extent to which the model can be improved significantly when releasing the constraint. If it significantly improves, that means that the relation is significantly different under different music conditions. In other words, there is an interactive effect of the independent variables on the hypothesized structure.

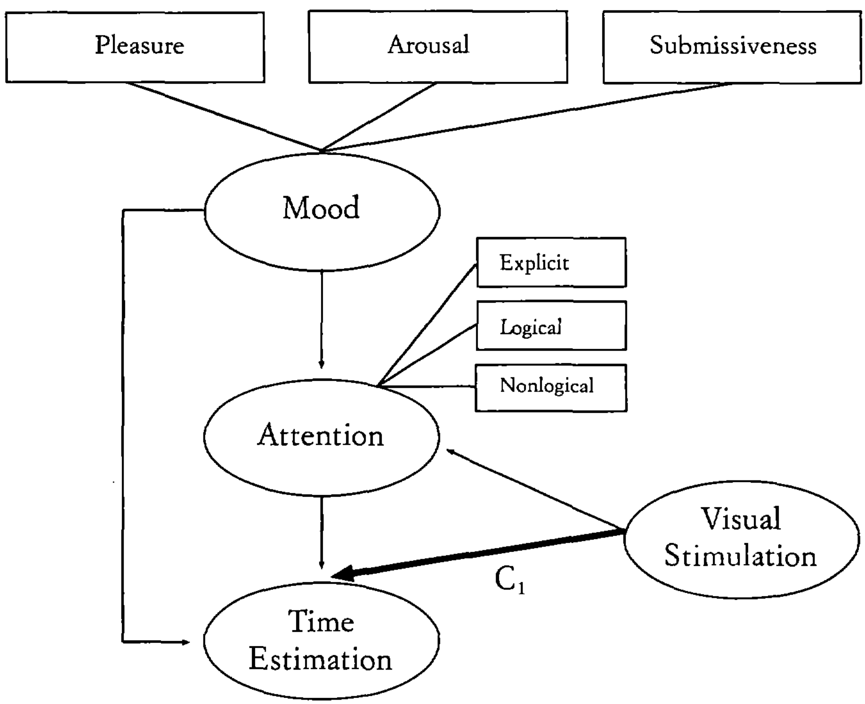

FIG. 4. Basic structural model

Such tests of the C_1 constraint were done for the three paired comparisons of no vs slow music, no vs fast music, and slow vs fast music.

Comparisons between no- vs slow-music conditions.—The Bentler-Bonett Normed Fit Index (or BBNI) was high (.97): The hypothesized model fitted well in both no- and slow-music conditions. The constraint was tolerated by EQS ($\chi_1^2 = .38$, $p = .54$). In other words, C_1 could be integrated into these two experimental conditions without reducing the goodness of fit.

Comparisons between the no- vs fast-music conditions.—BBNI was high (.94) but results showed that the constraint C_1 was not accepted ($\chi_1^2 = 6.64$, $p = .01$): C_1 was rejected, the relation between visual stimulation and time estimation was different under no and fast music.

Comparisons between slow- vs fast-music conditions.—Here too, BBNI was high (.96) and constraint C_1 was not accepted ($\chi_1^2 = 4.40$, $p = .03$). The relation between visual stimulation and time proved to be different under fast music than under slow music. In short, goodness of fit was high for all cases: the structural model made sense. Constraint C_1 should be released since the effect of visual stimuli on time estimates was significantly different under fast music than under the two other musical conditions.

The next step of the structural analysis was to use the EQS procedure for each of the three musical conditions. In all cases, the model tested was the same as those of the basic model, as expressed in Table 1.

The 'no-music' model (3.1).—The statistics of fit and the parameters' es-

TABLE 2
THE EQS MODEL PARAMETERS AND INDEXES

	No Music	Slow Music	Fast Music
Normed Bentler-Bonett Goodness of Fit Index	0.986	0.960	0.920
χ^2	18.59	11.17	18.88
df	16	17	20
p	0.300	0.850	0.530
Root Mean Square Residual	0.030	0.020	0.040

Parameters	β	*t*	*p*	β	*t*	*p*	β	*t*	*p*
Mood→Pleasure	1.000			1.000			1.000		
Mood→Arousal	0.951	2.39	.01	1.172	2.31	.03	0.925	2.12	.05
Mood→Submissiveness	0.786	2.49	.03	0.967	2.62	.01	0.793	2.31	.03
Attention→Explicit	1.000			1.000			1.000		
Attention→Logical	1.284	2.69	.01	1.125	2.53	.03	1.394	2.46	.01
Attention→Nonlogical	1.409	2.60	.01	1.563	1.83	.08	1.544	2.24	.03
Mood→Attention	−0.175	−2.26	.03	0.290	0.80	ns	0.027	0.67	ns
Visual→Attention	0.111	2.26	.03	−0.087	2.05	.05	0.054	1.78	.09
Attention→Time	−0.239	1.82	.08	0.040	0.85	ns	0.024	1.28	ns
Mood→Time	0.103	1.15	ns	0.232	2.43	.03	0.040	1.42	ns
Visual→Time	0.280	2.07	.05	0.169	1.88	.07	−0.084	0.95	ns

timate for this model appear in Table 2. The χ_{16}^2 for this model was 18.59. This statistic may be used to test the model against the alternative unconstrained model (no causal links). In other words, the χ^2 allowed us to test the null hypothesis (i.e., the hypothesized model is the same as the model contained in the data). In such a case, the fact of accepting the null hypothesis means that the model derived from the EQS procedure reproduces well the original data.

Results showed that the original model fitted well for the 'no-music' condition (BBNI = .986); the χ_{16}^2 (18.59) based on the remaining 16 degrees of freedom was not significant ($p = .30$) which means that we accepted the null hypothesis: the EQS procedure reproduced well the original data. The average absolute standardized residuals were low (0.03).

The significant parameters estimated are those illustrated in boldface in Fig. 5. The significant relations of the 'no-music' model were: higher visual stimulation enhanced time estimates, higher visual stimulation enhanced attention, higher attention reduced time estimates, and higher mood reduced attention.

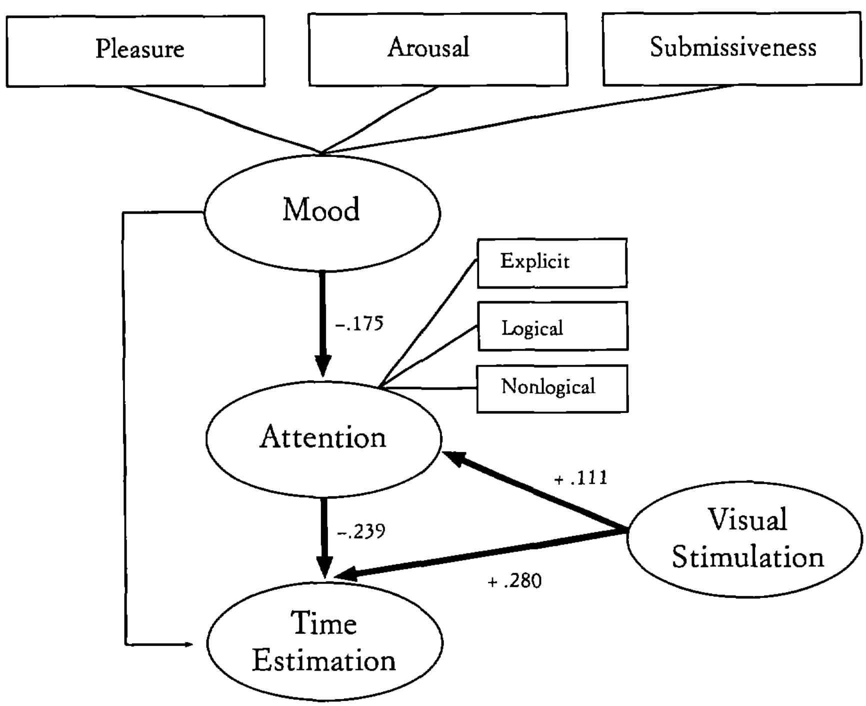

FIG. 5. The no-music model

The 'slow-music' model (3.2).—The BBNI is high (.960); χ_{17}^2 of 11.17 was not significant, so the null hypothesis was accepted here too ($p = .85$). The EQS model reproduced the original data well. See Table 2. The average absolute standardized residuals were low (0.0178). The significant parameters estimated are those in boldface in Fig. 6. The significant relations of the 'slow-music' model were: visual stimulation had a negative effect on attention, visual stimulation had a positive effect on time estimation, and the higher the mood, the longer the time estimates.

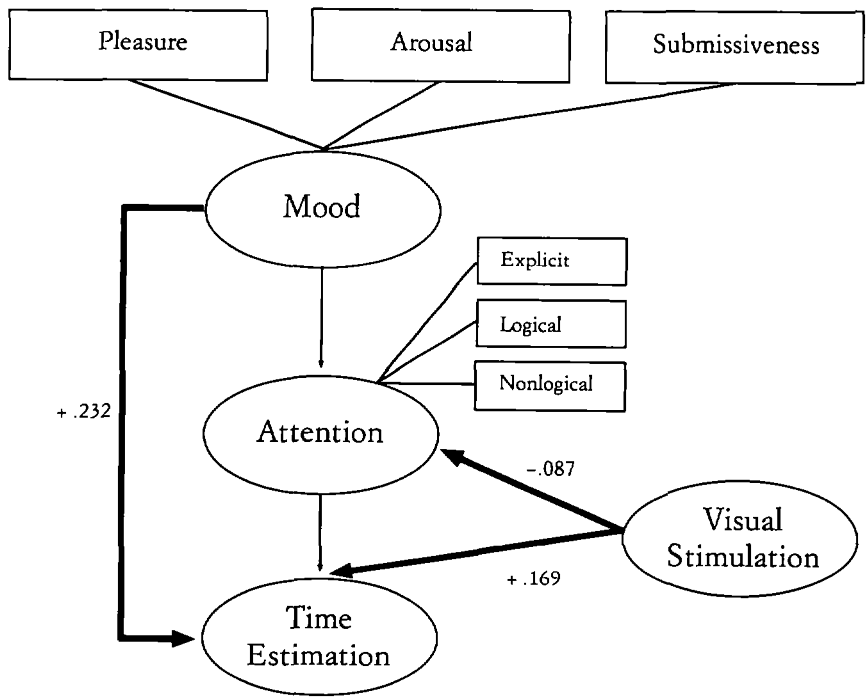

FIG. 6. The slow-music model

The 'fast-music' model (3.3).—The statistics of fit and the parameters' estimate for this model appear in Table 2. The BBNI was very high here too (.92); the χ_{20}^2 of 18.89 was not significant ($p = .53$), which leads us to accept the null hypothesis, *viz.*, a good reproduction of the original data. The average absolute standardized residuals were low (.03).

Fig. 7 shows the significant parameters for the 'fast-music' model. The only significant relation was the effect of visual stimulation on attention: the higher the stimulation, the higher the attention.

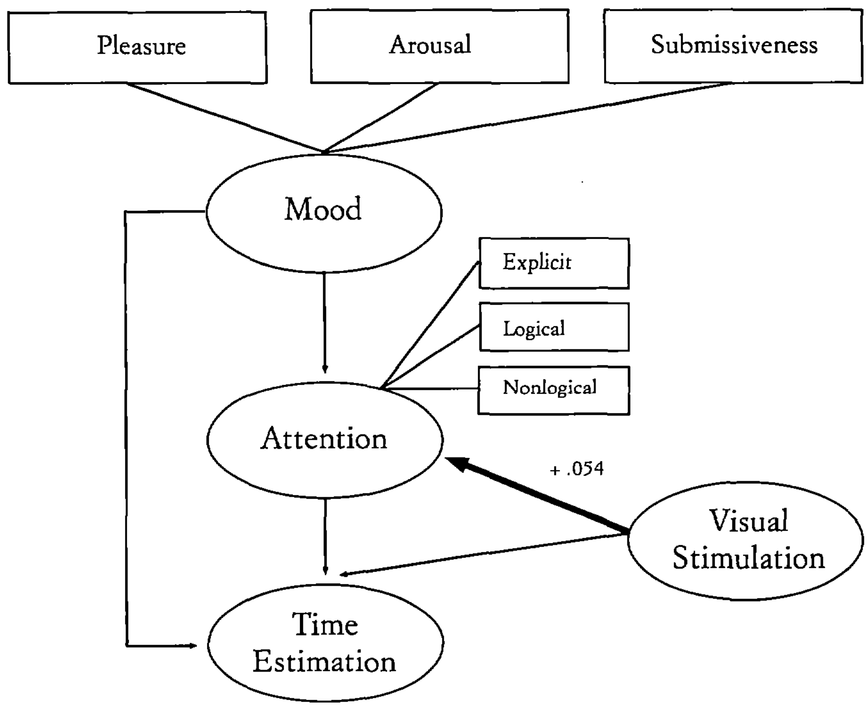

FIG. 7. The fast-music model

DISCUSSION AND CONCLUSION

The key result of this study is that music affects the dependent variable, i.e., time estimates, and the mediating variables, i.e., mood and attention; however, it mainly affected them as a moderator. A moderator variable was defined (e.g., Sharma, Durand, & Gur-Arie, 1981, p. 291) as "a variable which modifies either the form or the strength of relation between a predicated and a criterion variable." Music had no direct effects; it mainly modified the structural relations between other variables.

Relation Between Mood and Attention

Under no music, the relation between mood and attention was negative: the lower the mood, the higher the attention. This result basically confirmed previous results reported above (Schwarz & Bless, 1991). Under both slow- and fast-music conditions, music cancelled the relation between mood and attention. It then could be reasoned that the very presence of music is likely to create a distracting effect from the visual cues. As pointed out by Madsen (1970, p. 324), "there is no such thing as simultaneous focus of attention."

In his study, musical background, whatever the tempo, was detrimental to focusing on reading. In ours, musical background was detrimental to paying attention to the visual cues of the videotapes. In both studies music presence was detrimental to attention to information received from vision.

Relation Between Attention and Perceived Time

Under the 'no-music' condition, the significant negative relation between attention and perceived time can be understood as follows. First, this result basically contradicted Ornstein's 'storage-size theory' (1969), which predicted that a positive relation between the amount of information recorded and the perceived time exists. Our results confirmed those of several researchers. Arlin (1986, p. 182) found "an inverse relationship between attentional demand and time perception"; Hanley and Morris (1982), Hawkins and Tedford (1976), and McClain (1983) also reported results contradicting Ornstein's theory. More importantly, our results confirmed clearly Zakay's (1989) and Hicks, *et al.*'s (1976) prediction that "a negative relationship between information-processing load was required during a target interval and its subjective duration" (Zakay, in press). Under both slow and fast music the attention-time relation is cancelled.

Zakay's (in press) Resource Allocation Model of Time Estimation has an interesting influence on our interpretation of our results. Our data were collected such that subjects had to assess duration of waiting time retrospectively. Then, this time assessment was mainly dependent on one of the two processors used by individuals who had to assess time durations, the 'information processor.' [Subjects are supposed not to use the 'processor of time' which is used mainly under the prospective context, i.e., when they know in advance that they have to assess time duration and then temporal information accumulates in this time processor (Zakay, 1989, in press).] Since music enhances distraction, this 'information processor' did not register and classify information properly. The attention-time assessment relation was then cancelled by the very presence of music.

Relation Between Mood and Time Estimation

Under slow music, mood affects time estimation; such a relation does not exist under both no- and fast-music conditions. This result can be explained as follows: under slow music the level of distraction is higher than under no music and lower than under fast music. It has been shown that slow music enhances the attention on a task more than fast music. On the contrary, fast music had a distracting effect (Stratton & Zalanowski, 1984), since our subjects had to assess time retrospectively and used mainly the 'information processor.' They assessed time with information which was reduced by the distracting effects of music. We propose that mood plays the role of the missing information. This idea was inspired by some previous studies.

Riskind (1989) suggested that it may be useful to think of mood as a cognitive state (rather than as a subjective feeling). Laird (1989) proposed that emotions may be considered as cognition in the self-perception process in which feelings arise from behavior. More specifically, in the retrieval of a recorded event, which is accomplished by addressing heading, each heading is made of a mixture of content—such as information from the environment—and internal states—such as mood (Morton, Hammersley, & Beherian, 1985). Our results can be interpreted as mood state serves as a substitute for information when the level of distraction is such that a part of the information has been either not recorded or not classified. Then a global mood self-assessment can be processed instead of the truncated information.

Under fast music, the level of distraction was even higher, and even more information failed to be either recorded or classified. In addition to its distractive effects, higher mood has been shown to affect the social information processing. Higher mood triggers a specific type of information-processing strategy, characterized by a lack of logical consistency and low attention to details (Schwarz & Bless, 1991). Consequently, under fast music, the distracting effects may have also hindered the introspective information process through which subjects assessed their own emotional state. The mood-time relation may then have been cancelled mainly because of the shallow information processing triggered by a high mood.

Visual vs Musical Cues' Effects on Time Estimates

In two studies cited above (Glenberg, *et al*, 1989; Schab & Crowder, 1989) the authors claimed that auditory cues are superior to visual ones in temporal accuracy. Does this superiority imply that auditory stimuli contain more temporal information than visual stimuli? In these two experiments subjects knew in advance that they had to focus their attention on temporal cues. In these experimental prospective conditions, subjects mobilized their attention on the information presented to them. It may well be that auditory cues are selected as containing the most valuable piece of information for the 'time processor' in a prospective context. Musical tempo can be an easy way of counting time units accumulating in the 'timer.' However, Bickel's results (1984) showed no effects of musical tempo on time estimation also in a retrospective context. Our study, as most experiences in real life, involved a retrospective time estimation, which involves mainly the 'information processor.' It is very likely that in a retrospective context visual cues (such as bank clerks working at the counter or customers waiting in line, or customer-employee interaction) contain more "events" easier to memorize and recall than classical music. Whereas music may be easily processed prospectively through the 'times' (which has not been found so far), visual cues are easier to store and process in a retrospective way through the 'information processor.'

Time vs Information Processors

The attentional model proved here too to be a better predictor of time estimations than the storage-size model developed by Ornstein (1969); however, the attentional model was apparently contradicted by the results related to Hypothesis H2.2: the higher the visual stimulation, the longer the time. It was reasoned that the more visual cues, the more attention was used to process them and, consequently, the less attention was left to time cues. This reasoning stemmed directly from the attentional models. However, this reasoning is based on the assumption that the information processing was mediated by attention. The EQS model and the tests of hypotheses show a more precise picture. The effects of visual stimulation on time estimation exist independently from the relation of visual stimulation on attention: the two relations are not interdependent.

This leads us to the following explanation for the apparent contradiction between our results on H2.2 and the attentional model's prediction. Under no music, the 'visual stimulation-attention-time' relation confirmed what the 'information processor' is hypothesized to do in a retrospective context. Under slow music and under no music, the direct and positive relation between visual stimulation and time was essentially what the 'time processor' is hypothesized to do in a prospective procedure. Under fast music, neither of the two processors seemed to be working.

Zakay (in press) did not suggest that it is either the information processor or the time processor which works under either retrospective or prospective experimental procedures; rather, he suggested that "in the retrospective context of time judgment, priority is given to the information processor: temporal information might also be registered in the time processor, but this information is casual and not available for making the time estimation."

Zakay (1989, p. 367) argued that the retrospective estimation must "rely heavily on data stored in long-term memory" because the estimator is "not aware of the need to pay attention to the passage of time." In fact, our results both confirm and disconfirm this perspective. It confirmed the negative relation between attention and time estimates, which is the basic assumption of the attentional model. It disconfirmed the idea that subjects use only the information processor in a retrospective context; our results showed that they used both simultaneously and, consequently, they did not rely only on long-term memory, as was suggested by Zakay.

Slow music did not have the straightforward effects on attention that Stratton and Zalanowski (1984) have shown. Our results showed that slow music enhanced attention if visual stimulation was also low. Our results also showed that fast music or absence of music can enhance attention if visual stimulation is high. This contradiction with results from Stratton and Zalanowski can be understood as follows: the laboratory conditions in which their experiment took place included low visual stimulation, which they did not study. It is clear that the interactive effects of visual and musical cues on attention need to be documented: the present study simply shows how complex these effects are.

Music vs Metronome and Time Estimates

Our results confirmed that of Bickel (1984): musical tempo has no direct effect on subjective estimation of time. Musical tempo does not play the same role as a metronome, the tempo of which does affect time estimation. The specific effects of music should be investigated in further studies, since only Bickel's study and ours show them. These effects should be tested in both retrospective and prospective contexts. It may well be that the absence of musical effects on time estimation is due to the retrospective context and not to the intrinsic nature of musical ones.

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