Mental Comparisons of Relative Positions with the Months of the Year: Stimulus and Instructional effects

by

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I dedicate this thesis to my parents who have always encouraged me to pursue my dreams and ambitions

ABSTRACT

This research dealt with the cognitive processes underlying mental comparisons of relative positions with the months of the year. It was intended to study 1) the mental representation of the months of the year, and 2) the semantic interpretation of positive and negative comparative instructions in the symbolic paired-comparison task.

Subjects, in Experiments 1 and 2, were asked to indicate which member of month pairs occurred earlier, later, less early or less late in the year. Non-monotone distance and congruity effects were obtained in both experiments. This result is consistent with the hypothesis of a multidimensional perception of the months of the year. Furthermore, the form of the congruity effects obtained with negative instructions was the exact reversal of those obtained with positive instructions. This result is consistent with the hypothesis of a recoding of all negative instructions into their positive equivalent before the comparison process begins.

The effect of the relative demands for speed vs. accuracy of responses on the magnitude of the congruity effect was examined in two other experiments. The magnitude of this effect on latency was found to be larger when more emphasis was put on accuracy than on speed of responses in Experiment 4. This result is consistent with the hypothesis of a "decisional" locus of the congruity effect and thus with all models which localize this effect in the decision process. Speed/accuracy tradeoff functions were also generated. Conclusions that pertained to the interpretation of the comparative instruction were based on changes observed in the form of this function for different forms of the instruction: A sign effect was detected only between-

subjects.

Finally, a fifth experiment was carried out in order to evaluate the hypothesis that the mental representation of the months of the year is not invariant but depends on the requirements of the task performed. Subjects were required to perform dissimilarity judgments. Multidimensional scaling analyses were then performed. The resulting similarity structures differed considerably from those obtained in the paired-comparison task. This result is consistent with the hypothesis of a context-sensitive mental representation of the months of the year.

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CHAPTER I

INTRODUCTION

MENTAL COMPARISONS OF RELATIVE POSITIONS

An important means of classifying and organizing information in long term memory consists in ordering sets of objects according to the extent to which they are perceived to possess a particular attribute. This type of organization enables us to perform comparisons between objects over a wide range of abstract and concrete continuous dimensions. However, the way in which such comparisons are performed is still in dispute. An experimental method commonly used to study mental comparisons consists of presenting subjects with a comparative instruction and two verbal stimuli; subjects then are required to choose as rapidly and as accurately as possible which stimulus possesses more (or less) of the attribute specified by the instruction.

Two types of stimulus sets have been used in mental comparison research: 1) Stimuli with a pre-experimentally defined ordering such as digits (Moyer & Landauer, 1967; Fairbank & Capehart, 1969; Parkman, 1971; Sekuler, Rubin, & Armstrong, 1971; Buckley & Gillman, 1974; Banks, Fujii, & Kayra-Stuart, 1976; Holyoak, 1978; Desrochers & Petrusic, 1983; Shoben, Cech, & Schwanenflugel, 1983), animal or object size (Moyer, 1973; Jamieson & Petrusic, 1975; Paivio, 1975; Banks & Flora, 1977; Holyoak, 1977; Desrochers & Petrusic, 1983; Foltz, Poltrock, & Potts, 1984; Bank & White, 1985; Cech & Shoben, 1985) and, letters of the alphabet (Lovelace & Snodgrass, 1971; Parkman, 1971; Hamilton & Sandford, 1978) and, 2) stimuli with an arbitrarily defined ordering, learned in the context of the experiment such as CVC-circle size associations (Moyer and Bayer, 1976), color-stick men size associations (Kosslyn, Murphy, Bemesderfer, & Feinsten, 1977), height of various professionals (Woocher, Glass, & Holyoak, 1978) and, height of fictitious men (Banks, White, & Mermelstein, 1980). The interests or preoccupations are, in both classes of studies, as Banks (1977) pointed out, of a different nature. The first class of studies deals with the representation of ordered information in semantic memory, that is the mental representation of ordered information which is a matter of common knowledge, linguistic convention or of real world knowledge. Inversely, the second class of studies deals with the representation of ordered information in short-term or episodic memory.

Another feature common to most mental comparison studies is that comparative instructions are presented in the form MORE X THAN (e.g., smaller/larger) and rarely in the form LESS X THAN (e.g., less small/less large). The semantic interpretation of both forms of the comparative instruction have been studied in tasks involving judgments of synonymity (Higgins, 1976;1977), judgments of acceptability (Higgins, 1977; Segui & Fourment, 1979), sentence verifications (Flores D'Arcais, 1970; 1974; Segui and Bertoncini, 1978) and, paired comparisons (Desrochers and Petrusic, 1983). However, the semantic interpretation of <u>all</u> possible forms of the comparative instruction has not been a central issue in mental comparison research.

GOALS OF THE PRESENT RESEARCH

The present research had two main objectives. First, it was intended to study the mental representation of a specific overlearned serial stimulus set, the months of the year, in the context of the symbolic paired-comparison task. Second it was intended to study more thoroughly the semantic interpretation of comparative instructions comprised of the adverb "more" or "less". For clarity, we shall refer to these instructions as positive and negative, respectively. Concerning the first issue, it has already been shown that the distance between both members of the stimulus pair, the symbolic distance (e.g., Moyer & Landauer, 1967; Fairbank, 1969; Parkman, 1971; Sekuler, Rubin & Armstrong, 1971; Moyer, 1973; Buckley & Gillman, 1974; Jamieson & Petrusic, 1975; Paivio, 1975; Holyoak & Walker, 1976; Banks, Fujii, & Kayra-Stuart, 1976; Holyoak, 1977; Desrochers & Petrusic, 1983), and the position of the stimulus pair in the linear sequence relative to the polarity of the instruction, the semantic congruity (e.g., Shipley, Coffin, & Hadsell, 1945; Shipley, Norris, & Roberts, 1946; Audley & Wallis, 1964; Wallis & Audley, 1964; Ellis, 1972; Friend, 1973; Jamieson & Petrusic, 1975; Banks, Fujii, & Kayra-Stuart, 1976; Holyoak & Walker, 1976; Holyoak, 1978; Desrochers & Petrusic, 1983; Petrusic & Baranski, 1989), affect subjects' responses. We were interested in determining if other characteristics of the stimuli, specific to the stimulus set chosen, could also affect subjects' responses and consequently the form of the commonly reported symbolic distance and semantic congruity effects. The months of the year were chosen as our stimulus set because they offered us the opportunity to examine the effect of several physical and semantic stimulus characteristics on the overall decision process in the paired-comparison task.

Concerning the second issue, it has already been demonstrated that negative comparative instructions are more difficult to process than positive comparative instructions (e.g.,Flores D'Arcais, 1970; 1974; Segui & Bertoncini, 1978; Desrochers & Petrusic, 1983). They are processed both less rapidly and less accurately than positive instructions. However, we have no clear idea yet of how the form of the instruction affects the overall decision process and at what stage in this process. How are negative instructions interpreted? What strategy do subjects use to perform the task with such instructions? We attempted to answer each of these questions in the present research.

Ultimately, the goal of this research was the identification of the major factors affecting the overall decision process in the symbolic paired-comparison task, and thereby, a more thorough understanding of this process itself. The mental comparison experiments reported here were conducted with French-speaking subjects and the instructions chosen were the four forms of the French comparative for temporal order: PLUS TOT "earlier", PLUS TARD "later", MOINS TOT "less early", and MOINS TARD "less late". These instructions have the advantage of sharing the same surface structure. This feature permitted us to separate the effect of the sign (expressed by the adverb) from that of the attribute (expressed by the adjective) of the instruction. For each month pair presented, subjects were required to indicate as rapidly and as accurately as possible which member of the pair occurred earlier, later, less early or less late in the year. We now turn to a more detailed discussion of the two general issues of this research.

MENTAL REPRESENTATION OF THE MONTHS OF THE YEAR

The months of the year are category labels which divide the calendar year into 12 roughly equal time intervals. This categorization system has three characteristics that are pertinent to the present research. First, it is acquired quite early in the child's cognitive development, and it is normally overlearned by adulthood. Second, it is serial and cyclic; it involves a conventional starting point and ordering, and the series is recurrent. Finally, this system is semantically rich in the sense that each month may be associated with distinct conventional, natural or personal events. Despite the importance of this categorization system in people's life, very few studies have been conducted on the cognitive properties of the months of the year.

Fairbank (1969) asked subjects to decide which member of month pairs was closer to the end of the year and noted the presence of a symbolic distance effect: Reaction times increased as the distance between both stimuli decreased.

Seymour (1980a, 1980b) had subjects classify the months on various binary attributes such as temperature (warm vs. cold weather), vegetal growth (plants grow vs. die), and periods of the year (central vs. peripheral months; first vs. second half). Subjects were presented with a month name and a statement such as "warm weather" or "centre" and were required to respond "yes" if the month corresponded to this statement and "no" if it did not. Two results obtained in such classification tasks led Seymour to believe that the mental representation of months of the year is essentially semantic, that is, that the months of the year are represented in long-term memory in terms of

"discrete componential codes of natural language" (Banks, 1977; p.131).

First, a sharp increase in reaction times was observed at the locus of each transition point between the segments relevant to the attribute under study (boundary effect). Second, an overall bias in reaction time and accuracy was noted in favor of the "yes" responses for central months and in favor of the "no" responses for peripheral months in both temperature-growth and center-end verification tasks (Month X Response interaction).

Seymour accounted for the boundary effect by hypothesizing two levels of cognitive coding for the representation of the months of the year. At a first level, the serial position of the month is characterized roughly by a set of discrete, linguistic categories (e.g., Start-Early-Center-Late-End). At a second level, the exact order of months falling into each category is established. Boundary effects occur, according to Seymour, because at "boundary locations" other than December-January, the discrimination allowed by the primary categorical codes is insufficient (e.g., Does July, coded as central, belong to the first or the second half of the year?). At these points, the finer secondary codes must be activated for the required discrimination to be made.

Seymour also noted that the ease of retrieval of adjacency information varies at different points in the month series. Access to this information is easier for the first, middle and last months (i.e., January, June, July, and December) than for all others. Conversely, such access appears to be particularly difficult for early and late months (e.g., April and September).

Seymour also accounted for the Month X Response interaction by arguing that subjects grouped the primary categorical codes on the bipolar dimensions of centrality (central-peripheral) and earliness (early-late). Central and early months have positive connotations (warm weather, vegetal growth) and thus will facilitate positive "yes" responses. Conversely, peripheral and late months have negative connotations (cold weather, death of plants) and thus will tend to facilitate negative "no" responses.

Friedman (1983) elaborated a two-process model in order to account for the performance on a large number of tasks in which months of the year have been used. By this account, two distinct cognitive systems underlie our knowledge of the months of the year: 1) a verbal-list system similar to Paivio's (1971, 1978) verbal symbolic system, and 2) an image system similar to the imagery mechanisms described by Kosslyn (1981) and Paivio (1978). These systems are said to serve best in different types of tasks. The contents of the verbal-list system are verbal chains of names and the main characteristic of this system is that elements are activated sequentially either vocally or covertly. From this characteristic, it follows that the activation of elements will be easier in their correct order than in the reverse order and that response times will increase monotonically as the number of elements activated also increases. The contents of the image system are spatial representations of objects and of schematizations such as circular or linear diagrams of the month cycle. The main feature of this system is the concurrent activation of numerous elements. The simultaneous availability of multiple parts of the image will then enable us to detect easily backward order and patterns such as the relative proximity of one month to two others.

Both systems were distinguished by comparing the magnitude of the distance and direction effects obtained in tasks designed to invoke either verbal or imaginal processes. Both effects were expected to be more pronounced in tasks invoking verbal processes than in those invoking imaginal processes. The tasks chosen to invoke verbal processes involved the determination of exact distances. Subjects were asked to decide which of two adjacent months came two or four steps after a third reference month. The tasks chosen to invoke imaginal processes involved judgments of relative proximity. In these tasks, subjects were required to choose which of two non-adjacent months came after a third reference month, moving forward or backward in the series. As predicted, the magnitude of the distance and direction effects differed substantially in both types of tasks. Both effects were much more pronounced in the tasks developed to elicit verbal processes than in those designed to elicit imaginal processes.

In a second study, Friedman (1984) examined the form of the proximity effects obtained in a comparison task involving cyclic relationships. Subjects were presented with two months and were asked to decide whether the second month was closer to the first one going forward or backward in time. Friedman attempted to confront the generality of analog and semantic comparative judgment models, by showing that only one of these two models could easily account for the performance on such a task. He suggested that imaginal processes were involved in performing this task and that although semantic models, such as Banks' semantic coding model, could easily account for the performance in tasks involving bipolar comparisons, they could not, as formulated, easily do so in tasks involving cyclic relations. Friedman predicted that, by analogy to a similar perceptual task, comparisons would become increasingly difficult as the second month approached a boundary region, corresponding to the month six steps away from the first month. He predicted linear and quadratic increases in difficulty as separations approached half of the month cycle. The results obtained confirmed this prediction. In addition, the patterns of reaction times and errors were very similar to those obtained in an equivalent spatial task. The author concluded that semantic models could not easily account for his proximity effects because

> "they depend upon bipolar or categorical descriptions of the items that are available in natural language". These descriptions "do not contain sufficient information to determine the relative cyclic order of items". Thus, these results "seem to weaken the status of existing semantic models as a general account of proximity effects in comparative judgments" (Friedman, 1984; p.312).

Seymour and Friedman revived a debate, which arised in the context of several influential studies concerned with the nature of the mental representation of the stimuli and with the processes involved in performing comparative judgments (e.g., Moyer and Landauer, 1967; Jamieson and Petrusic, 1975; Moyer and Bayer, 1976; Banks, Fujii and Kayra-Stuart, 1976; Banks, 1977; Holyoak, 1978). The results presented as supporting evidence for a semantic vs. an analog representation of the months of the year, however, do not constitute irrefutable proofs. First, the presence of boundary effects and of the Month by Response interaction does not necessarily imply the involvement of semantic codes. One very important class of analog models, the reference point models (Marks, 1972; Jamieson and Petrusic, 1975; Holyoak, 1978) can very easily account for the presence of distance and congruity effects in the comparative judgment task. It could also account for the presence of Seymour's boundary effect and Month by Response interaction. Second, the prediction of smaller distance and direction effects in tasks involving judgments of relative order or relative proximity than in those involving a determination of exact distances is too vague a criterion to justify the conclusion of the involvement of imaginal processes in the former tasks. One must wonder what constitutes a strong or a small distance or direction effect. Third, the observation of similar reaction time functions in the month tasks and analogous perceptual or spatial tasks

> "cannot be taken to establish that the symbolic task depends on utilization of a physical or analogue code" (Seymour, 1980b; p.261).

What must be determined here is whether perceptual comparisons (such as comparisons of line lengths) can involve the use of discrete, linguistic, semantic codes or not. Finally, Friedman (1984) argued that Seymour's semantic coding model could not account for the performance in comparison tasks involving cyclic relationships between months. Seymour's model could account for the performance on such a task by assuming that a closer/further judgment will be performed by deciding whether the second month presented is far or close relative to the first month when going forward in time. If the second month is coded as close to the first month, the response "closer forward" is chosen. Conversely, if the second month is coded as far from the first month, the response "closer backward" is chosen. Holyoak (1978) had, in a similar fashion, suggested that Bank's semantic coding model could account in such a way for the performance in his numerical triplet tasks. It is interesting to note that although Friedman cited the studies of Banks (1977) and Holyoak (1978), he did not mention at all the occurrence of congruity effects in these studies. The occurrence of such an effect and the predictions derived concerning its form in different experimental conditions have been of central importance in the debate over a semantic vs. an analog representation of the stimuli in comparative judgments.

It is clear that both Seymour's and Friedman's models need to be further developed so as to enable distinct predictions concerning the form of the distance and congruity effects obtained in comparative judgment tasks. Several aspects of both models are not yet sufficiently articulated. We have, for instance, no idea of how the primary and secondary codes are generated in Seymour's model and, of how images or schematic representations of the month cycle are formed in Friedman's image system. The present research was not intended to resolve this debate. Rather, it was meant to determine the characteristics of the months of the year which can influence the overall decision process in the paired-comparison task. The month series, unlike other stimulus sets is very rich semantically and thus possesses several attributes which may influence the overall decision process in this task. In what follows, different properties or characteristics of the month series will be identified which may influence the overall decision process in this task and consequently, the form of the obtained distance and congruity effects.

First, Seymour's boundary effects and Friedman's proximity effects suggest that the proximity of month pairs to the boundary dividing the month series into two segments on to the bipolar early/late continuum will largely affect the difficulty of the overall decision process. As month pairs approach this boundary region, responses will become slower and less accurate. Central adjacent month pairs (i.e., May-June, June-July, July-August) should then be processed less rapidly and accurately than other pairs because of their proximity to the June-July boundary dividing the month series in half. However, since, as Seymour's data suggest, retrieval of adjacency information appears to be particularly easy for central months June and July as well as for end months January and December, adjacent central pairs and end pairs are likely to yield relatively short comparison latencies and high percentages of correct responses. Consequently, the global form of the predicted congruity effects and distance effects obtained with central months (i.e., May, June, and July) should be that of an inversed W for response latencies and of a W for percentages of correct responses.

Furthermore, September may, on some trials, be viewed as the starting point of the month series since it corresponds to the beginning of the school year and all our subjects were students. Thus, the pair August-September may be overall much more discriminable and hence much easier to process than pairs such as July-August or October-November. Relative to this boundary, only the two members of the first pair fall in different categories (August is a late month and September, an early month).

SEMANTIC INTERPRETATION OF THE COMPARATIVE INSTRUCTION

Comparative instructions that express inequality relations are normally used to order two or more objects on a given semantic dimension. Four different types of surface structures may be used to express the same order relation between two objects: X is later than Y (X>Y), Y is earlier than X (Y<X), Y is less late than X (Y<X), and X is less early than Y (X>Y). Comparative instructions convey not only explicit information concerning the relative position of the compared objects but also implicit information concerning their absolute position on the underlying semantic dimension. The presuppositional nature of comparative instructions has been found to vary as a function of their linguistic structure, that is, as a function of their sign and attribute, in synonymity (Higgins, 1976; 1977) and acceptability judgment tasks (Higgins, 1977; Segui and Fourment, 1979). Similarly, the comprehension of comparative instructions has been found to be largely influenced by their linguistic structure in sentence-verification (Flores D'Arcais, 1970; 1974; Segui & Bertoncini, 1978) and paired-comparison tasks (Desrochers & Petrusic, 1983). Instructions containing strong presuppositions concerning the absolute position of the compared objects on the underlying semantic dimension were, in these tasks, difficult to process. Thus, responses were generally faster and more accurate for instructions containing the adverb "more" than for those containing the adverb "less" (sign effect), and for instructions containing an unmarked adjective than for those containing a marked adjective (lexical marking effect). The lexical marking effect was also more pronounced if the sign of the instruction was negative than if it was positive (This last effect was reported only by Segui & Bertoncini, 1978, and Desrochers & Petrusic, 1983).

Huttenlocher and her collaborators (Huttenlocher, Higgins, Milligan, & Kauffman, 1970; Huttenlocher & Higgins, 1971) have proposed that, in the process of interpreting negative instructions, subjects usually recode them into a positive form that preserves the expressed order relation. Furthermore, they suggested that this recoding is probabilistic and that its likelihood increases if the instruction also contains a marked adjective. A more constraining version of this recoding hypothesis, elaborated by Segui and Bertoncini (1978), states that instructions are recoded only when they contain both the adverb "less" and a marked ratio adjective. In what follows we will consider Huttenlocher and her collaborators' version of the recoding hypothesis which is consistent with both the reported main effect of the sign of the instruction and the Sign X Markedness interaction.

Aside from this recoding of the instruction, other strategies may be used in the process of interpreting negative instructions. Different types of instruction or stimulus recoding can be performed at different points in the overall decision process. This hypothetical recoding operation has important consequences for the form of the congruity effect obtained in mental comparisons. The predicted form of this effect depends on both the type of recoding done and the processing stage at which it occurs. An examination of the form of the congruity effect obtained with positive vs. negative instructions should thus shed some light on how both forms of instructions are processed and, consequently, enable an evaluation of Huttenlocher and her collaborators and of Segui and Bertoncini's recoding hypothesis. In order to make a clear distinction between the possible forms of the congruity effect, we shall consider different situations in which only two of the four possible forms of the comparative instruction are presented: earlier vs later; less early vs less late; earlier vs less early; and later vs less late. In brief, either the sign or the attribute of the instruction is kept constant in each condition.

We now shall examine the empirical consequences of different recoding scenarios developed in the context of two different comparative judgment models. The two models are Banks' (1977) semantic coding model and Holyoak's (1978) reference point model. However, before presenting the different scenarios, both models will briefly be described. As originally formulated, both of them cannot account for the interpretation of negative instructions. However, they can be extended to do so.

BANKS' SEMANTIC CODING MODEL

According to Banks' semantic coding model, mental comparisons involve three sequential processing stages: 1) The production of discrete semantic codes for the instruction and the stimuli, 2) the comparison of the instruction and stimulus codes, and finally 3) the selection of the correct response when a match occurs. The function of the encoding stage is to generate discriminable semantic codes for the instruction and each member of the stimulus pair. In a comparison task with the months of the year, the instructions "earlier" and "later" will be coded E+ and L+, respectively, and the stimuli will be coded either earlier (E+) or later (L+) than a given cutting point in the month series. When both stimuli are coded E+ or L+, more information must be accumulated in order to permit the creation of distinguishable codes (E+/E "very early/early", E/E+ "early/very early", L+/L "very late/late" or, L/L+ "late/very late"). At the next stage, the two stimulus codes are compared to the instruction code in order to enable the selection of the correct response. If both stimulus codes cannot be matched to the instruction code, they are recoded so as to enable the occurrence of a match with the instruction. So for example, if the instruction is coded E+ and the two months compared are coded L and L+, the codes for both stimuli will be transformed into E+ and E, respectively. The time required to recode the stimuli is said to account for the semantic congruity effect. Figure 1.1 summarizes the main processing stages of this model. We now consider three recoding strategies that may be applied when a negative instruction is presented. For the sake of simplicity, we assume that the presentation of all negative instructions always results in some form of recoding and that all transformations of cognitive codes require roughly the same

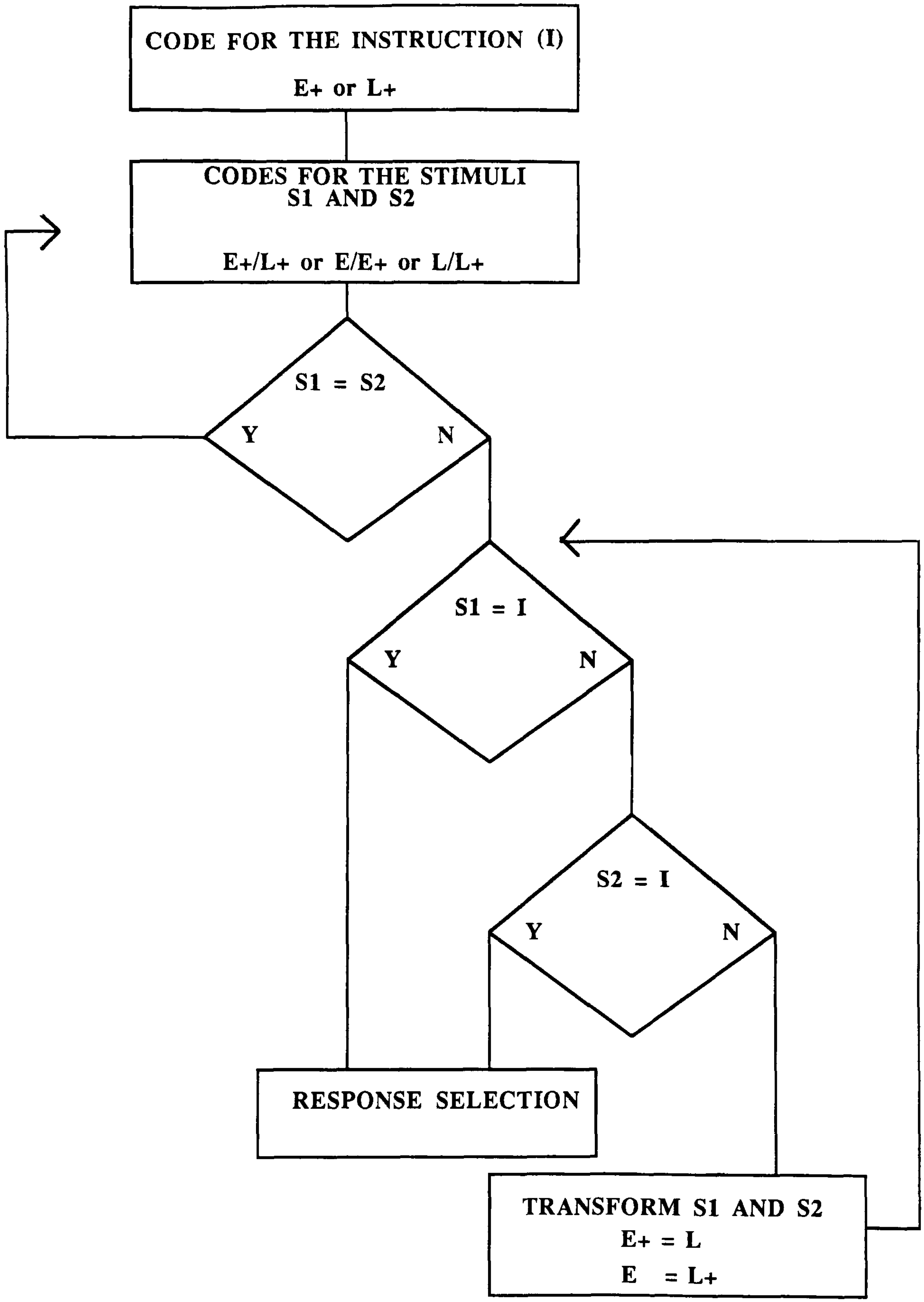

Figure 1.1 Schematic representation of Banks' 1977 semantic coding model

amount of time.

According to the first strategy, subjects recode the instruction into a positive form during the encoding stage (i.e., L- "less late" into E+ "earlier"; E- "less early" into L+ "later"). By the second strategy, they recode the stimuli instead of the instruction, from a positive to a negative form, during the comparison stage. One or two stimulus recodings will be necessary depending on the position of the stimulus pair on the underlying continuum. The stimulus recodings may also occur in two ways: 1) Stimuli at locations congruent with the attribute of the instruction will require two recodings; conversely, those at incongruent locations will require only one recoding (L = E+, L+ = E-, E = L+ and E+ = L-) or 2) stimuli at locations congruent with the attribute of the instruction will require only one recoding; conversely, those at incongruent locations will require two recodings (L = L , L+ = L+, E =E- and E+ = E+). According to the first type of stimulus recoding, if the instruction is coded L- and the stimuli E and E+, these stimuli will be recoded into L+ and L-. However, if the stimuli are coded L and L+, two stimulus recodings are necessary. They will first be recoded into E+ and E- and then, into L- and L+ According to the second type of stimulus recoding, if the instruction is coded L- and the stimuli, L and L+, the stimuli will be recoded into L and L+. However, if the stimuli are coded E and E+, they will be recoded into E- and E+, and then into L+ and L-. Finally, according to the third strategy subjects focus mainly on one element of the instruction, the adjective. They store in working memory the actual sign of the instruction and perform all comparisons as if it was positive. They then transform the response codes if the instruction was negative. We now present an alternative theoretical model before we derive the consequences of these recoding scenarios on the form of the congruity effect.

HOLYOAK'S REFERENCE POINT MODEL

According to this model, symbolic paired comparisons involve the following processing stages: 1) the activation of a reference point specified by the instruction, 2) the representation of each comparison stimulus by an analog value on the specified attribute, 3) the assessment of the distance from each stimulus representation to the reference point and 4) the comparison of both derived distances. Both distances are compared by obtaining a ratio of the smallest difference on the largest. The value of this ratio varies from 0 (maximally discriminable stimuli) to 1 (maximally non-discriminable stimuli). The difficulty of the comparison increases as the distance ratio approaches unity, and this ratio approaches unity for comparison stimuli far from the reference point. If instructed to choose which of two months comes earlier, subjects compare the distance from each item to the lower bound of the month series, January, and choose the stimulus closest to it. Similarly, if instructed to choose which of two months comes later, subjects compare the distance from each item to the upper bound of the month series, December, and choose the stimulus closest to it. Figure 1.2 summarizes the main processing stages of this model. With negative instructions, the correct response may be chosen by performing a further judgment instead of a closer judgment. Hence accounting for how negative comparatives are processed amounts here to accounting for how further judgments are performed, and more specifically, further judgments with unilateral pairs since in the paired-comparison task the stimulus pair is necessarily unilateral. Both members of the pair fall on the same side of the reference point.

According to a first strategy, subjects recode the instruction into a positive form during the encoding stage, by selecting the reference point at the pole of the continuum opposite to that suggested by the adjective, and then perform a closer

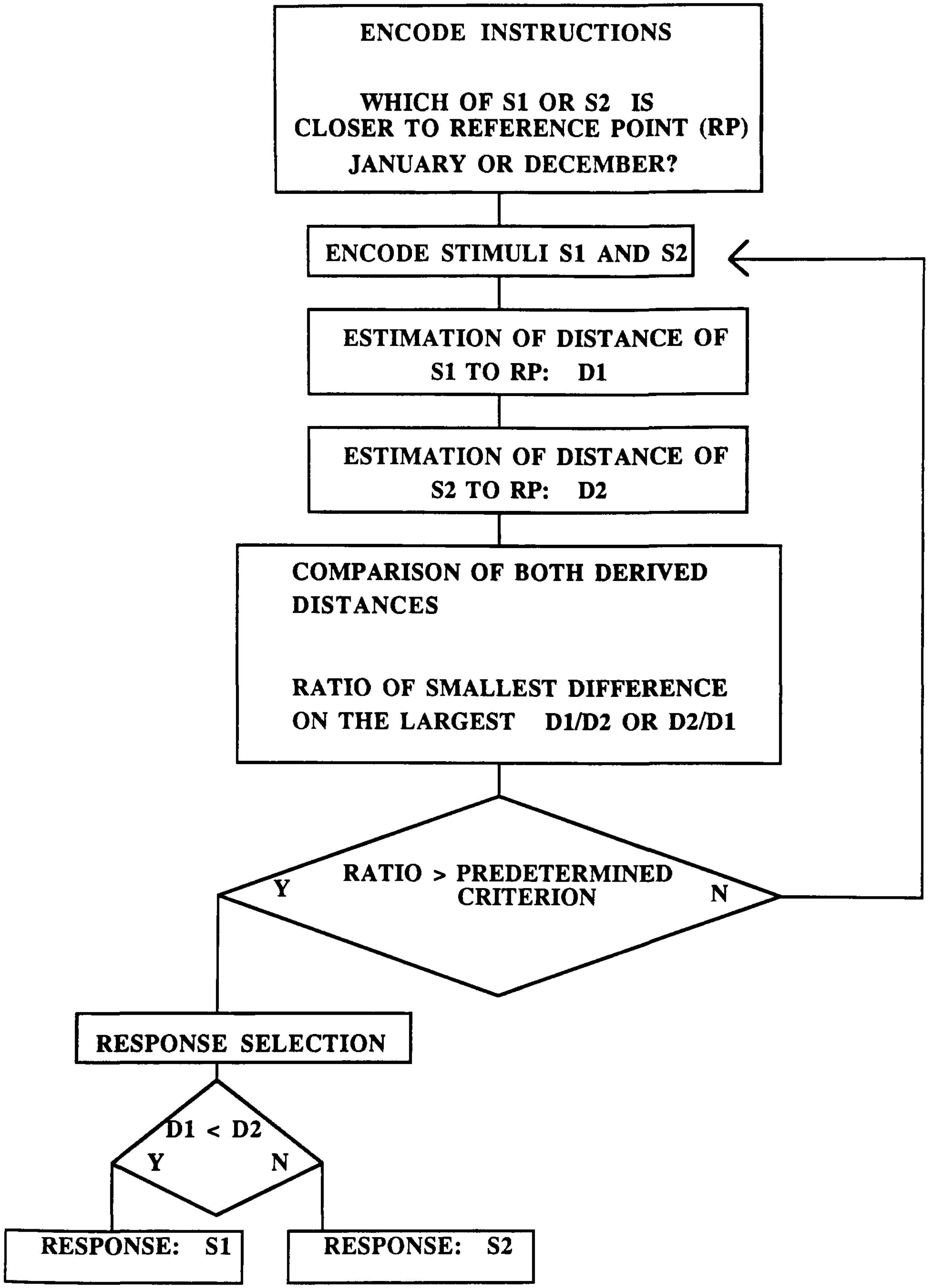

Figure 1.2 Schematic representation of Holyoak's 1978 reference point model

judgment. By a second strategy, they perform a closer judgment by directly choosing the stimulus closer to the pole referred to by the attribute of the instruction and then switch responses.[1]

All scenarios derived from Banks' semantic coding model and Holyoak's reference point model yield a specific prediction concerning the form of the congruity effect obtained with negative instructions when either the sign or the attribute of the instructions is kept constant in a particular experimental condition. Figure 1.3 illustrates these predictions on response times. The first panel to the left in this figure refers, for each scenario, to the condition "earlier/later" (E+/L+). The next panels refer to the conditions "less early/less late" (-E/-L), "less early/earlier" (-E/E+), and "less late/later" (-L/L+), respectively. The expected form of this effect is in all cases, as predicted in the previous section, that of an inversed W.

Banks' and Holyoak's scenario 1 predict the presence of a crossover congruity effect in all conditions. The form of this effect with negative instructions is the exact reversal of that obtained with positive instructions. This reversal occurs because the recoding of the instruction takes place before the comparison process begins. A latency component is also added to the total reaction time of negative instructions to account for the recoding operation. Furthermore, positive instructions are overall processed less rapidly when presented in conjunction with negative instructions (in conditions "less early/earlier" and "less late/later") than when not (in condition

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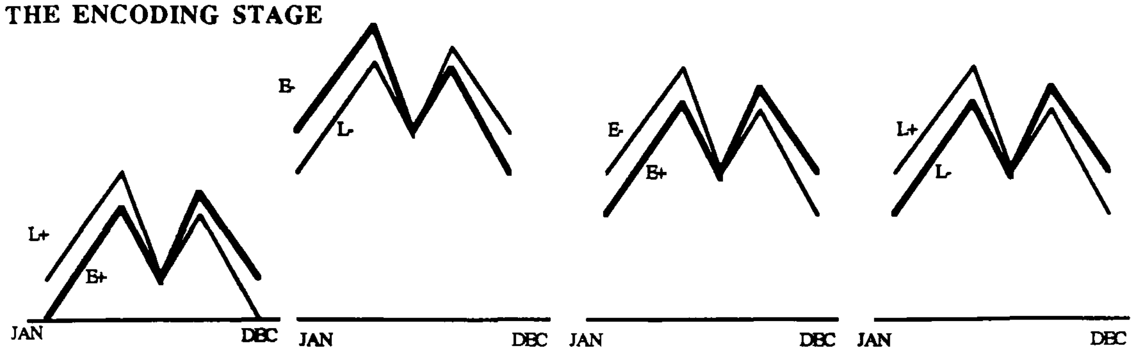
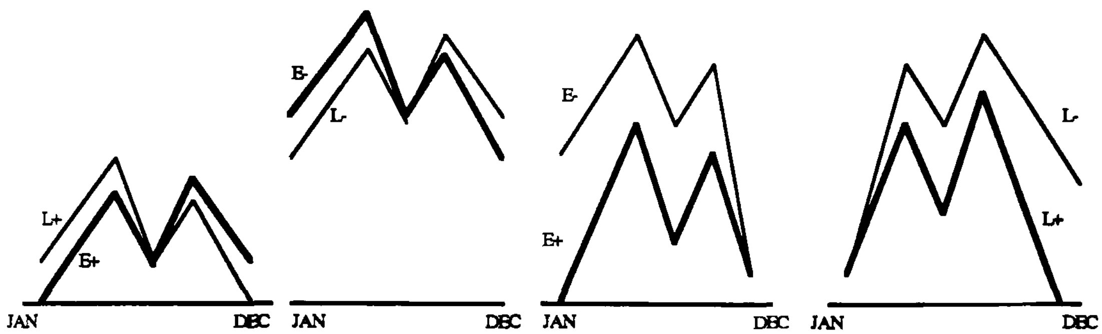
[1] Holyoak also outlined two other possible scenarios to account for how further judgments are performed. These two strategies were first to decide whether the stimulus pair is higher or lower than the RP and then 1) choose the earlier month if the pair is above the RP or the later month if the pair is below the RP and then switch responses or 2) choose the later month if the pair is above the RP and or the earlier month if the pair is below the RP. These two strategies appear to be much less economical than the first two strategies we have described. Furthermore, we believe that the selection of the earlier or later month in both strategies may amount to performing closer judgments as those depicted in the first two strategies.

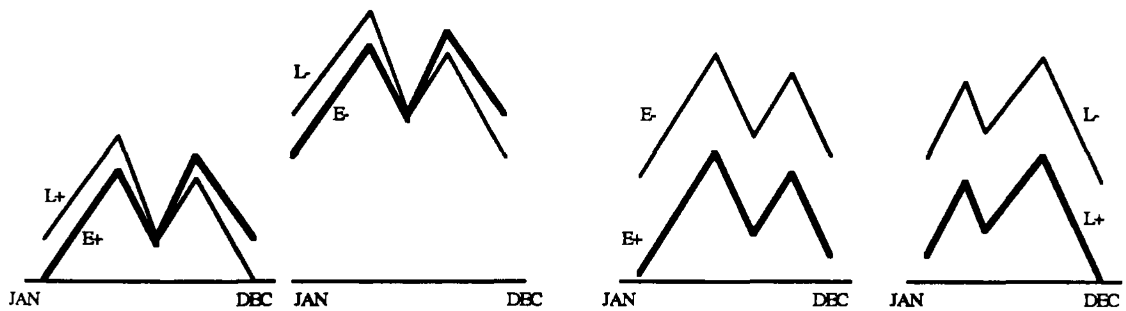
BANKS' AND HOLYOAK'S SCENARIO 1: RECODING OF THE INSTRUCTION DURING THE ENCODING THE ENCODING STAGE



BANKS' SCENARIO 2: RECODING OF THE STIMULI DURING THE COMPARISON STAGE. STIMULUS RECODING OF TYPE 1 (L+=E-, L=E+, E+=L-, E=L+)



STIMULUS RECODING OF TYPE 2 (L+=L+, L=L-, E+=E+, E=E-)



BANKS' SCENARIO 3 AND HOLYOAK'S SCENARIO 2: CORRECT RESPONSE SELECTED ONLY BY ATTENDING TO THE INSTRUCTION'S ATTRIBUTE

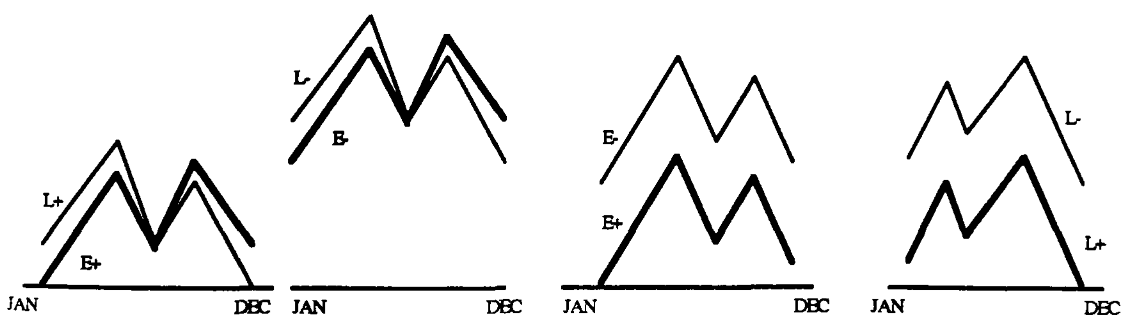


Figure 1.3 Schematic representation of the predicted forms of the congruity effect obtained with positive and negative comparative instructions according to three distinct scenarios derived from Banks' and Holyoak's models

"earlier/later") since in the former conditions a decision must first be taken during the encoding stage as to whether the presented instruction is positive or negative.

Banks' second scenario also predicts the presence of a crossover congruity effect in conditions in which the instruction's attribute varies and its sign is constant. However, the form of this effect is determined by the type of stimulus recoding performed. If the stimulus recoding is of type 1, stimuli at locations congruent with the attribute of the instruction are those which require two recodings. The expected form of the crossover effect is thus identical to that of scenario 1, that is, the exact reversal of the pattern obtained with positive instructions. Conversely, if the stimulus recoding is of type 2, stimuli at locations incongruent with the attribute of the instruction are those which require two recodings. The expected form of the crossover effect is, in this case, determined by the instruction's attribute. It has the same form as that obtained with positive instructions. In conditions in which the sign of the instruction varies and its attribute is constant, this scenario predicts the presence of a funnel-shaped congruity effect if the stimulus recoding is of type 1, with the opening of the funnel located at the extremity of the stimulus ordering congruent with the instruction's attribute. However, if the stimulus recoding is of type two, this scenario predicts the presence of parallel non overlapping curves. In this case, negative instructions always require one recoding more than positive instructions.

Finally, the predicted form of the congruity effect obtained with negative instructions in Banks' third scenario and Holyoak's second scenario is determined entirely by the attribute of the instruction. For the condition in which the instruction's sign is constant and its attribute varies, the congruity effect for negative instructions has the same form as that predicted for positive instructions, with a latency component added to account for response code switching. For the condition in which the attribute is kept constant and the sign varies, parallel curves are predicted. Response latencies are longer both for positive and negative instructions if the stimulus position is incongruent with the attribute of the instruction than if it is congruent. Again, a latency component is added for the switching of responses.

As can be seen, both models essentially do not make different predictions concerning the form of the congruity effect obtained with negative instructions. However, it is now clear that the two model can both, with minor modifications, easily account for the comprehension of negative instructions. The present research enables a test of Huttenlocher and her collaborators (1970,1971) and of Segui and Bertoncini' (1978) recoding hypothesis. An examination of the form of the congruity effect obtained with positive and negative instructions will enable us either to bring further confirmation to this hypothesis or to reject it.

CHAPTER II

STIMULUS AND INSTRUCTIONAL EFFECTS IN PAIRED-COMPARISONS WITH THE MONTHS OF THE YEAR

This chapter reports two experiments designed to evaluate the recoding scenarios developed in the context of Banks' semantic coding model and of Holyoak's reference point model in order to account for the interpretation of negative instructions, as well as our predictions concerning the mental representation of months of the year in the paired-comparison task. Both experiments involved two groups of subjects. In the first experiment, the sign of the instruction (more vs. less) was a between-subjects variable, while the polarity of the attribute (early vs. late) was a within-subjects variable. The first group of subjects was presented with the instructions "earlier and "later", while the second group of subjects was presented with the instructions "less early" and "less late". Conversely, in the second experiment, the polarity of the attribute was a between-subjects variable, while the sign of the instruction was a within-subjects variable. The first group of subjects in this experiment was presented with the instructions "earlier" and "less early", while the second group of subjects was presented with the instructions "later" and "less late".

Method of Experiments 1 and 2

Subjects

Forty undergraduate students enroled in a Psychology introductory course at the University of Ottawa served as paid volunteer subjects. Each experiment involved two conditions with ten subjects randomly assigned to each condition. All subjects were native speakers of French and had not participated in a symbolic comparison experiment previously. They received 25$ for completing seven one-hour sessions.

Material and equipment

The materials included all non-identical pairwise combinations of the 12 months of the year (i.e., 132 pairs) and the four forms of the French comparative for time order: PLUS TOT "earlier", PLUS TARD "later", MOINS TOT "less early", and MOINS TARD "less late". Each instruction appeared horizontally near the center of a Sysdyne DF 1331 video monitor, and both members of the stimulus pair were shown slightly below, one on each side of the instruction. Timing, sequencing, presentation of instructions and stimuli, and recording of responses and reaction times were controlled by an IBM XT microcomputer. Subjects were seated in front of a table which supported the video monitor and a panel containing eight response keys. The first and eighth keys were labelled "left" and "right", respectively, and were used to express the response. The six middle keys served only to initiate the onset of the next trial.

Procedure

Subjects were tested individually in a quiet room. They were asked to press the key to the side of the month that matched the displayed instruction and to respond as rapidly and as accurately as possible. They also were instructed to think of the months of the year as a linear series spanning from January to December. The instructions to respond quickly but accurately and to think of the months as a linear series were repeated at the beginning of each session.

Both experiments involved seven sessions of 552 self-paced trials each. These 552 trials included: (a) 24 practice trials, and (b) two blocks of 264 experimental trials (i.e., 66 non-identical pairs X 2 left-right presentation orders X 2 comparative instructions). Subjects were instructed to take a short break between each of the two blocks of experimental trials. Each trial consisted of the following sequence of events: a) A fixation point (plus sign) appeared at the center of the video monitor and remained visible on the screen for 500 msec; b) An instruction and a stimulus pair appeared simultaneously and remained in view until the subject made a response; and c) a message was shown to remind the subject to press one of the middle keys to initiate the next trial. No feedback was given for accuracy or speed. The order of the trials was random and this random order differed on each block and for every participant in the experiment.

Results and discussion

The results obtained in both experiments are presented under two sub-headings, namely, the mental representation of the months of the year and the semantic interpretation of the comparative instruction. Two aspects of subjects' performance were examined: 1) response times and 2) response accuracy. The dependent variables for all analyses carried out were mean response times in msec and mean percentages of correct responses.

THE MENTAL REPRESENTATION OF THE MONTHS OF THE YEAR

To examine the symbolic distance among the stimuli, the mean response times and mean percentages of correct responses were plotted for month pair separations of one to six (Separations larger than six were not considered since for such separations, the number of observations was judged too small). These values were averaged over specific month pairs, blocks of trials, left-right presentation order of the stimuli, instructions, sessions and subjects. A symbolic distance effect was clearly observed on response latency and accuracy in both experiments. Thus, as the distance between both members of the month pair increased, overall both response latencies and percentages of incorrect responses decreased. An analysis of variance performed with one within-subjects variable (symbolic distance) and one between-subjects variable (experimental condition), confirmed the significance of the symbolic distance effect in both experiments on response latency, $F(5,90)=86.45$, $p<.0001$, $F(5,90)=50.15$, $p<.0001$ and response accuracy, $F(5,90)=33.25$, $p<.0001$, $F(5,90)=15.74$, $p<.0001$. The Distance X Condition interaction was significant on both latency and accuracy only in the second experiment, $F(5,90)=4.02$, $p<.002$, and $F(5,90)=3.42$, $p<.007$. A test of simple main effects indicated that the distance effect was more pronounced in the first (EARLIER/LESS EARLY) than in the second condition (LATER/LESS LATE) on both latency ($F(5,90)=40.91$, $p<.0001$; $F(5,90)=13.26$, $p<.0001$) and accuracy ($F(5,90)=15.57$, $p<.0001$; $F(5,90)=3.59$, $p<.005$). Figures 2.1 and 2.2 illustrate the overall distance effect obtained in each condition on response latency and response accuracy, respectively.

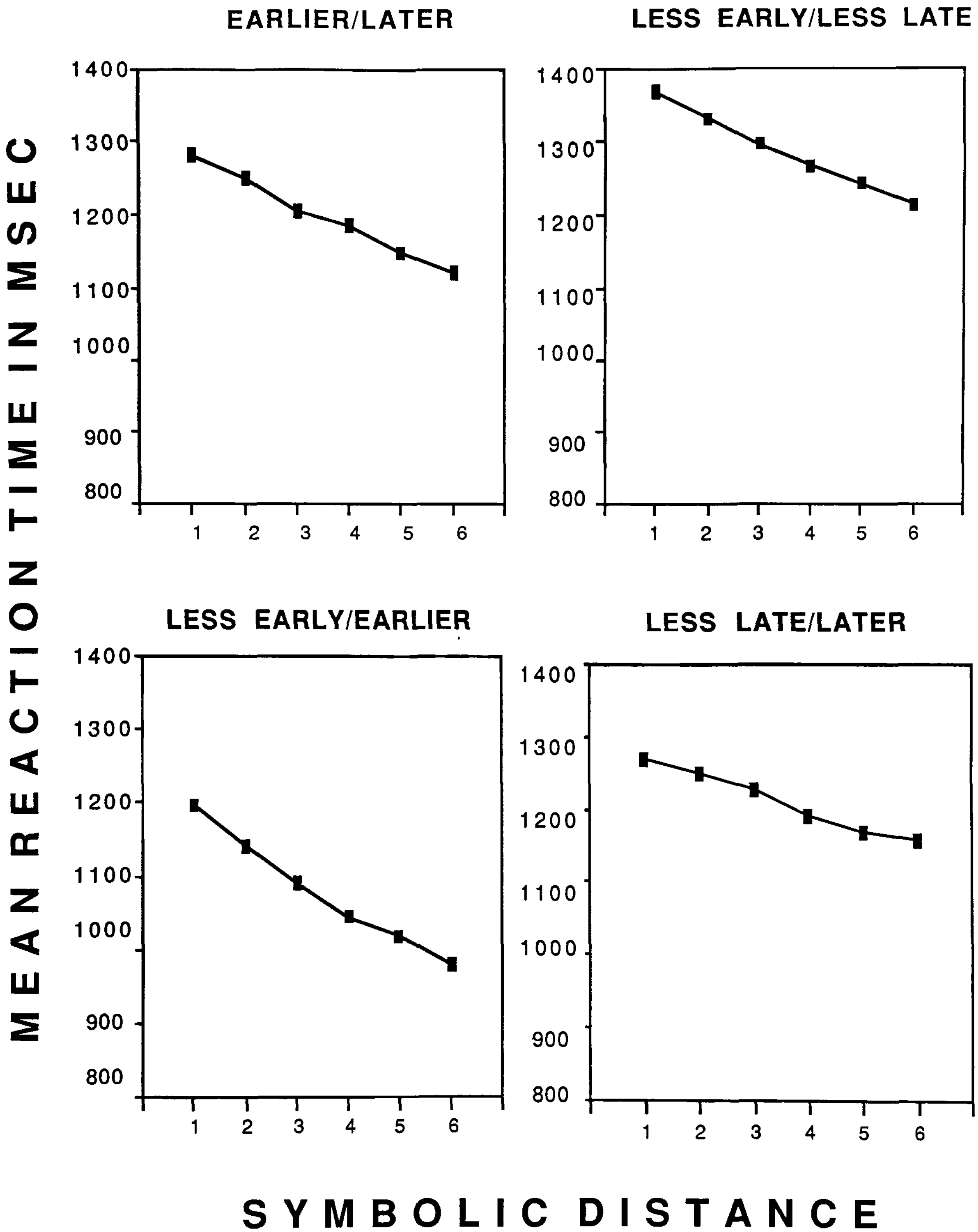


Figure 2.1 Overall symbolic distance effects obtained on mean latencies in conditions 1 (earlier/later, less early/earlier) and 2 (less early/less late, less late/later) of Experiments 1 and 2

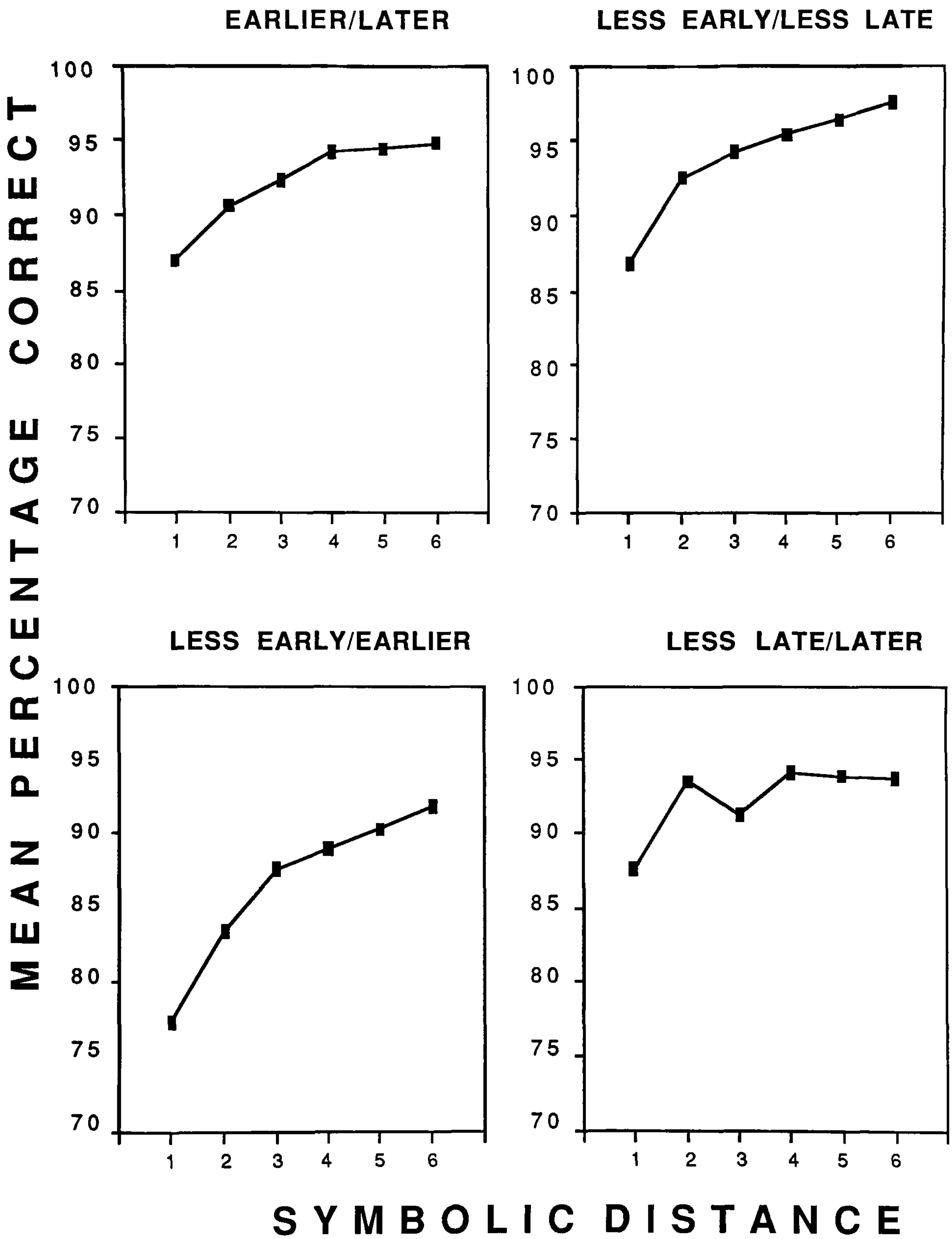


Figure 2.2 Overall symbolic distance effects obtained on mean percentages of correct responses in conditions 1 (earlier/later, less early/earlier) and 2 (less early/less late, less late/later) of Experiments 1 and 2

Two peculiarities of the distance effect, however, became apparent when drawing a separate plot of this effect for each of the 12 months used as reference month. First, the magnitude of the distance effect varied according to the considered reference month. Second, violations in the monotonocity of the symbolic distance function were noted for several of the reference months. The distance effect was not, overall, as finely graded as previous examinations of the global distance effect, collapsed over pairs, had erroneously suggested (e.g., Friedman, 1984). The plots of the distance effect for each of the 12 reference months are presented in appendix A.

An analysis of variance was performed in both experiments for each reference month separately with one within-subjects variable (symbolic distance) and one between-subjects variable (condition). Here also only distances ranging from 1 to 6 were tested, since the number of observations for separations of 7 to 11 was judged too small. An estimate of the size of the distance effect for each reference month was also computed in each experiment. The statistic used in order to do so is the partial eta-squared[2]. The results of the analysis of variance are presented in appendix B. As well, the estimates of the size of the distance effect are presented in appendix C.

The main results of these analyses in both experiments, consisted in a decrease in the magnitude of the distance effect on both dependent variables as the considered reference month approached one of the extremities (i.e., January or December) of the month series. The magnitude of this effect on response accuracy also tended to decrease as the reference month approached the center (i.e., June or July) of the month series. The distance effect on response accuracy thus tended to be most pronounced for the intermediate reference months April, May, September and October.

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[2] The partial eta squared is the only measure of size effect available with the SPSSX procedure MANOVA. This statistic is calculated in the following way: (df of the effect of interest) * (its F value)/(df of the effect of interest) * (its F value) + (df of error term). This measure overestimates the actual size effect. However, it is a consistent measure and is applicable to all F and t tests.

Finally, the Symbolic distance by Condition interaction was significant with both dependent variables only in the second experiment. The distance effect on latency was more pronounced in the first ("less early/earlier") than in the second condition ("less late/later") for ten of the twelve reference months. This effect on accuracy was also present only in the first condition for eight of the twelve reference months. The results of the simple main effect tests performed for each dependent variable are presented in appendix D.

An additional phenomenon apparent in the plots of the distance effect for each of the 12 reference months relates to a discontinuity in the distance effect pattern for several reference months. Violations in the monotonocity of the effect were apparent when examining adjacent month pairs: Response latency and accuracy varied tremendously from one pair to the other, and in several cases, these pairs were processed more rapidly and accurately than pairs with larger separations. This phenomenon is particularly evident in the distance function of reference months June and July. Although one might have expected the comparison between June and May or June and July to be slower and less accurate than, for instance, the comparison between June and April, June and August or May and July, overall the reverse pattern was obtained. Furthermore, central pairs May-June and June-July were processed more rapidly and accurately than the pairs April-May and July-August, which also are adjacent in the month series. This finding is not necessarily inconsistent with the boundary effects noted in Seymour's (1980a, 1980b) binary classification tasks and with the proximity effects noted in Friedman's (1983, 1984) proximity and cyclic direction tasks. Rather, it suggests, as proposed by Seymour, that retrieval of adjacency information is very easy at certain points in the month series, namely at the beginning, center, and end of the series.

The violations of monotonocity and the variations in the magnitude of the distance effects noted above strongly suggest that our perception of the months of the year is not unidimensional. The symbolic distance between both members of the stimulus pair cannot alone account for all the variations noted in response latency and accuracy. Groupings based on other characteristics of the stimuli also occur in the month series. These specific characteristics influence both response latency and accuracy, and consequently the form of the obtained distance effects. In order to gain more information on the nature of the groupings occurring in the month series, a nonmetric multidimensional scaling (MDS) analysis was performed on response times[3] in all conditions[4]. Mean response times for all stimulus pairs collapsed over presentation order were scaled by using the weighted individual differences euclidian distance model, as proposed by Carroll and Chang (1970). Response time has proved to be, in several previous studies, a reliable measure of confusability and, therefore, of similarity (Buckley and Gillman, 1974; Shepard, Kilpatric, and Cunningham, 1975; Monahan and Lockhead, 1977; Petrusic and Jamieson, 1979; Podgorny and Garner, 1979; Takane and Sergent, 1983; Sergent and Takane, 1987). In the present and previous studies just mentioned, latencies are assumed to be inversely related to stimulus dissimilarities, and consequently to distances in the stimulus configuration. This is in fact the basis for applying nonmetric MDS to response time data. In the present study, the members of month pairs with large response times are assumed to be very similar one to the other and are located near one another in the stimulus configuration. Inversely, members of month pairs with small response times are assumed to be dissimilar and are far apart in the configuration.

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[3] A multidimensional scaling analysis was not performed on response accuracy because not enough errors were committed in two out of four conditions. Response accuracy was overall less sensitive to variations in decision difficulty than response latency.

[4] The program used for this analysis was ALSCAL implemented in SPSSX, which uses the alternating least-square approach proposed by Takane, Young and deLeeuw (1977) and later improved by Young, Takane and Lewyckyj (1978). The data were treated 1) as similarities, 2) as being ordinal, using Kruskal's (1964) least-squares transformation, and 3) as being continuous.

In both conditions of Experiments 1 and 2, three-dimensional solutions accounted best for the response time data[5]. In all cases, three characteristics of the months of the year appeared to influence the overall decision process. By visual inspection of the configuration, these characteristics were interpreted as being, in order of importance, in Condition 1 of Experiment 1 (PLUS TOT/PLUS TARD) and Condition 2 of Experiment 2 (PLUS TARD/MOINS TARD): 1) the symbolic distance between both members of the month pair, 2) the presence or absence of an end term in the month pair (January or December), and 3) the part of the year in which the months fell (first vs. second half). In Condition 2 of Experiment 1 (MOINS TOT/MOINS TARD), they were interpreted as being: 1) the symbolic distance, 2) the part of the year in which the months fell, and 3) the presence or absence of an end term. Finally, in Condition 1 of Experiment 2 (PLUS TOT/MOINS TOT), these characteristics were interpreted as being: 1) the symbolic distance, 2) the position of the months according to the distinction center/periphery, and 3) the presence or absence of an end term.

A multiple linear regression analysis was performed in each condition in order to assess the validity of the above interpretations. Each of the stimulus characteristics identified above (1) symbolic distance, 2) part of the year in which the months fell, 3) presence or absence of an end term in the month pair, 4) position of the months according to the distinction center/periphery were in turn used as the dependent variable and the coordinates of the configuration for each dimension, as the independent variables. One other dependent variable considered consisted in the length of the month names. This stimulus characteristic was also considered because, in all four conditions, it appeared possible to interpret the first dimension as reflecting either symbolic distance or the length of month names. Furthermore, several subjects spontaneously reported relying on this stimulus characteristic to perform their

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[5] These solutions had stress values (Kruskal's form 1) and squared correlations in distances (RSQ), averaged over matrices, of 0.192 and 0.765, and 0.205 and 0.711 in conditions 1 and 2 of Experiment 1, and of 0.162 and 0.849, and 0.213 and 0.692, in conditions 1 and 2 of Experiment 2, respectively.

judgments. A weighted combination of the coordinates of the configuration was seeked which agreed with each of the identified stimulus characteristics. Kruskal and Wish (1978) have proposed this technique as a method of dimensional interpretation. The independent variables (dimensions 1, 2 and 3) were entered in the equation in a stepwise fashion and the criterion chosen for entry was a significance level of .05. Table 2.1 summarizes the results obtained in both conditions of Experiments 1 and 2. Two pieces of information are given for each dependent variable (stimulus characteristic): 1) the standardized regression coefficients, indicating the relative weight of each dimension accounting for the dependent variable, and 2) the multiple correlation (R) between this variable and the identified significant dimensions.

The results of this analysis indicated first that, overall, four of the five stimulus characteristics were well fitted by at least one of the three dimensions. The only stimulus characteristic poorly fitted, was the position of the months according to the distinction center/periphery. Second, they indicated that different dimensional interpretations were often possible, that is, often more than one stimulus characteristic mapped onto a given dimension. The first dimension could, for instance, be interpreted as reflecting either the symbolic distance, the length of months names or the part of the year in which the months fell. This finding is what constitutes the most important difference between the present and the previous visual interpretation of the stimulus configuration. This particular result can be explained by the fact that these three stimulus characteristics are not independent from one another. They are intercorrelated. Month pairs associated with small distances often fall in the same part of the year, and both members of the pair often have names of similar length. The results of this analysis also indicated that combinations of two or three dimensions often constituted better predictors of a stimulus characteristic than did a single dimension. Symbolic distance was, in all conditions, best fitted by a combination of dimensions 1 and 2 or 1, 2 and 3. Finally, an examination of the regression coefficients revealed that, in all conditions, the first dimension predicted better the length of month

Table 2.1 Results of a multiple linear regression analysis performed as a method of interpretation of MDS solutions in Experiments 1 and 2

Condition 1, Experiment 1 ("earlier/later")

Dependent variable	Standardized regression coefficients			R
Distance	Dim 1: .63	Dim 2: .43	Dim 3: .50	.97
End terms			Dim 3: .72	.72
1rst/2nd part	Dim 1: .50	Dim 2: .65		.92
Center/periphery				n.s.
Length of names	Dim 1: .79			.79

Condition 2, Experiment 1 ("less early/less late")

Dependent variable	Standardized regression coefficient			R
Distance	Dim 1: .65	Dim 2: -.59		.90
End terms	Dim 1: .29	Dim 2: -.87	Dim 3: -.33	.99
1rst/2nd part	Dim 1: .69			.69
Center/periphery				n.s.
Length of names	Dim 1: .88			.88

Condition 1, Experiment 2 ("less early/earlier")

Dependent variable	Standardized regression coefficient			R
Distance	Dim 1: -.84	Dim 2: .57		.92
End terms			Dim 3: .65	.65
1rst/2nd part	Dim 1: -.84	Dim 2: .46		.87
Center/periphery		Dim 2: .58		.58
Length of names	Dim 1: .88			.88

Condition 2, Experiment 2 ("less late/later")

Dependent variable	Standardized regression coefficient			R
Distance	Dim 1: .55	Dim 2: .66	Dim 3: .26	.97
End terms		Dim 2: .98		.98
1rst/2nd part	Dim 1: -.65	Dim 2: .40	Dim 3: .45	.97
Center/periphery				n.s.
Length of names	Dim 1: -.83			.83

names than the symbolic distance or the part of the year in which the months fell. This dimension, nonetheless, predicted adequately the other two characteristics. Next, the two other dimensions were most often best represented by the part of the year in which the months fell and the presence or absence of an end term in the month pair.

Mean response time for the 66 month pairs collapsed over presentation order, also were regressed, in each experiment, on the five stimulus characteristics identified above and on the variable "experimental condition". Overall, the results of this analysis confirmed those obtained in the previous regression analysis. The only difference was the order of importance of the significant stimulus characteristics identified. This difference in results is not surprising since the fit between the response time data and the MDS solutions was not perfect. In the first experiment, the results of the present analysis revealed that the variables significantly accounting for variations in response times were, in order of importance, when considering partial correlations: 1) the condition, 2) the presence or absence of an end term in the month pair, 3) the length of month names, 4) the symbolic distance, and 5) the part of the year in which the months fell. In the second experiment, the variables which significantly predicted response times were, in order of importance, when considering partial correlations: 1) the experimental condition, 2) the presence or absence of an end term in the month pair, 3) the symbolic distance, and 4) the length of month names. The correlation between response times and the respective set of variables was in both experiments equal to .88. Table 2.2 summarizes the results of this analysis.

What clearly comes out from all these results is that the symbolic distance between both members of the stimulus pair is not the only stimulus characteristic which affected the overall decision process in the present task. Aside from this variable, the three following stimulus characteristics also appeared to affect response latencies: 1) the length of months names, 2) the presence or absence of an end term in the month pair, and 3) the part of the year in which months fell. Several subjects reported relying

Table 2.2 Results of a multiple linear regression analysis performed on mean latencies in Experiments 1 and 2

Experiment 1 Independent variable	R	RSQ	Part Cor
Distance	.62	.38	.23
Experimental condition	.75	.56	-.42
End term	.84	.70	.42
Length of name	.88	.77	-.25
1st/2nd half	.88	.78	-.11
Experiment 2 Independent variable			
Distance	.55	.30	.36
Experimental condition	.75	.57	.52
End term	.85	.72	.41
Length of name	.88	.77	.24
1st/2nd half			

largely on the length of month names as a cue for lateness of the months in the year. Comparisons were performed much slower when both members of the stimulus pair had names of similar length than when they had names of different length. Comparisons were also performed much slower when both members of the month pair fell in the same part of the year (first or second half) than when they did not. Finally, latencies were much shorter when the stimulus pair contained an end term than when it did not.

THE SEMANTIC INTERPRETATION OF THE COMPARATIVE INSTRUCTION

To examine the effects reflecting the comprehension of the comparative instruction, analyses of variance were performed on both dependent variables with two within-subjects variables (session and polarity of the instruction's attribute in experiment 1; session and sign of the instruction in experiment 2) and one between-subjects variable (sign of the instruction in experiment 1; polarity of the instruction's attribute in experiment 2). Subjects and Reference months served only as replication factors. Mean percentages of correct responses and mean response latencies obtained on each session for each form of the instruction are reported in table 2.3. The analyses carried out on the data obtained in Experiment 1 revealed the presence of two significant effects: a) Globally, latencies decreased from sessions 1 to 7, $F(6,108)=36.60$, $p<.0001$; and b) responses to negative instructions were slower than those to positive instructions only on the first session, $F(1,18)=5.58$, $p<.03$. As for response accuracy, only one significant effect was detected. Instructions containing both the adverb "less" and the marked adjective "early" globally yielded a larger percentage of correct responses than instructions containing only one or none of these two elements, $F(1,18)=4.44$, $p<.049$.

The same analyses performed on the data obtained in Experiment 2 yielded six statistically significant effects: a) response times monotonically decreased from sessions 1 to 7, $F(6,108)=39.54$, $p<.0001$; b) responses to negative instructions were globally

Table 2.3 Mean response latency (in msec) and percentage of correct responses on each session as a function of the sign and the attribute of the instruction

Instruction	Experiment 1		Experiment 2	
	Latency	Accuracy	Latency	Accuracy
Session 1				
PLUS TOT (earlier)	1370	.93	1443	.88
PLUS TARD (later)	1379	.92	1382	.94
MOINS TOT (less early)	1650	.95	1548	.84
MOINS TARD (less late)	1653	.93	1430	.93
Session 2				
PLUS TOT (earlier)	1273	.95	1160	.88
PLUS TARD (later)	1256	.95	1243	.94
MOINS TOT (less early)	1345	.95	1217	.87
MOINS TARD (less late)	1329	.94	1263	.95
Session 3				
PLUS TOT (earlier)	1257	.93	1047	.87
PLUS TARD (later)	1244	.94	1198	.94
MOINS TOT (less early)	1231	.95	1079	.85
MOINS TARD (less late)	1211	.94	1231	.94
Session 4				
PLUS TOT (earlier)	1135	.92	1004	.88
PLUS TARD (later)	1133	.93	1147	.94
MOINS TOT (less early)	1178	.94	1013	.88
MOINS TARD (less late)	1164	.93	1150	.93
Session 5				
PLUS TOT (earlier)	1118	.92	938	.87
PLUS TARD (later)	1104	.92	1101	.93
MOINS TOT (less early)	1210	.94	948	.87
MOINS TARD (less late)	1229	.95	1127	.92
Session 6				
PLUS TOT (earlier)	1078	.91	886	.88
PLUS TARD (later)	1049	.92	1154	.94
MOINS TOT (less early)	1161	.94	881	.89
MOINS TARD (less late)	1174	.94	1170	.93
Session 7				
PLUS TOT (earlier)	1126	.92	871	.88
PLUS TARD (later)	1094	.93	1060	.93
MOINS TOT (less early)	1142	.94	857	.89
MOINS TARD (less late)	1152	.93	1080	.92

slower than those to positive instructions, $F(1,18)=8.59$, $p<.009$; c) when considering each session separately, this effect was, however, apparent only on the first three sessions, $F(1,18)>4.28$, $p<.053$; d) responses to instructions containing the adjective "late" were slower than those to the instructions containing the adjective "early" only on the last two sessions, $F(1,18)>6.22$, $p<.022$; e) a Sign X Markedness interaction was apparent only on the last session, indicating that the double-negative comparative instruction "less early" was on this session processed most rapidly, $F(1,18)=5.86$, $p<.026$; and f) the percentage of correct responses was larger with instructions containing the adjective "late" than with those containing the adjective "early" (93.6 vs. 87.3), $F(1,18)=4.89$, $p<.04$.

To sum up, an effect of the sign of the instruction was present only on response latency, on the first session in Experiment 1 and on the first three sessions in Experiment 2. This effect appears to be quite transient; with extended practice, it can be drastically reduced or even neutralized. Furthermore, an effect of the attribute of the instruction was detected on response latency and accuracy only in Experiment 2, and was in the expected direction only for response accuracy. Note that the adjectives used in this study were ratio as opposed to ordinal adjectives. Such adjectives involve a metric and a true zero point, and thus describe a ratio scale. Inversely, ordinal adjectives lack both characteristics and can only be rank ordered (Huttenlocher & Higgins, 1971; Higgins, 1976; 1977). The absence of a consistent lexical marking effect (i.e., an advantage of "late") with response latencies thus lends support to Huttenlocher and Higgins' (1971) and Higgins' (1977) claim that both unmarked and marked regular ratio adjectives, as opposed to their ordinal counterparts, do not contain strong presuppositions concerning the absolute position of the stimuli on the underlying semantic dimension, and thus can be interpreted neutrally. Furthermore, our results do not confirm Segui and Bertoncini's (1978) recoding hypothesis. According to this hypothesis, the instruction containing both the adverb "less" and the marked adjective "early" is maximally complex because it constitutes a case of double-negative and consequently must be transformed into its positive equivalent. In our study, this instruction was not, unlike what this hypothesis would predict, processed slower nor less accurately than instructions containing only the adverb "less" or the marked adjective "early" (i.e., less late; earlier).

Finally, one very important finding of this research related to the form of the semantic congruity effect obtained with positive and negative comparative instructions. The mean response time and mean percentage of correct responses for each of the adjacent month pairs were plotted separately for each of the two presented instructions. These data were averaged over blocks of trials, presentation order of the stimuli, sessions and subjects. A congruity effect was observed in all conditions only on response latency; only three out of 40 subjects did not show this effect. As expected, this effect was non-monotone. Figures 2.3 and 2.4 illustrate this effect on response latency and accuracy, respectively.

The global form of this effect on response latency was, as predicted, in all conditions, that of an inversed W. Furthermore, the pair August-September was, as expected, processed more rapidly than the pairs July-August and September-October in three out of four conditions. This pair may have been easily discriminable either because in several cases September was viewed as an early month since it corresponds to the beginning of the school year, or because in French the month names August and September are of clearly different length. These patterns of non-monotonocity again are consistent with the hypothesis of privileged access to adjacency information at certain points in the month series and consequently with that of a multidimensional perception of the months of the year in the symbolic paired-comparison task. It is now clear that stimulus characteristics other than the symbolic distance and the position of the stimulus pair in the linear sequence relative to the polarity of the instruction's attribute, affect response latencies, and, consequently, the form of the obtained distance and congruity effects.

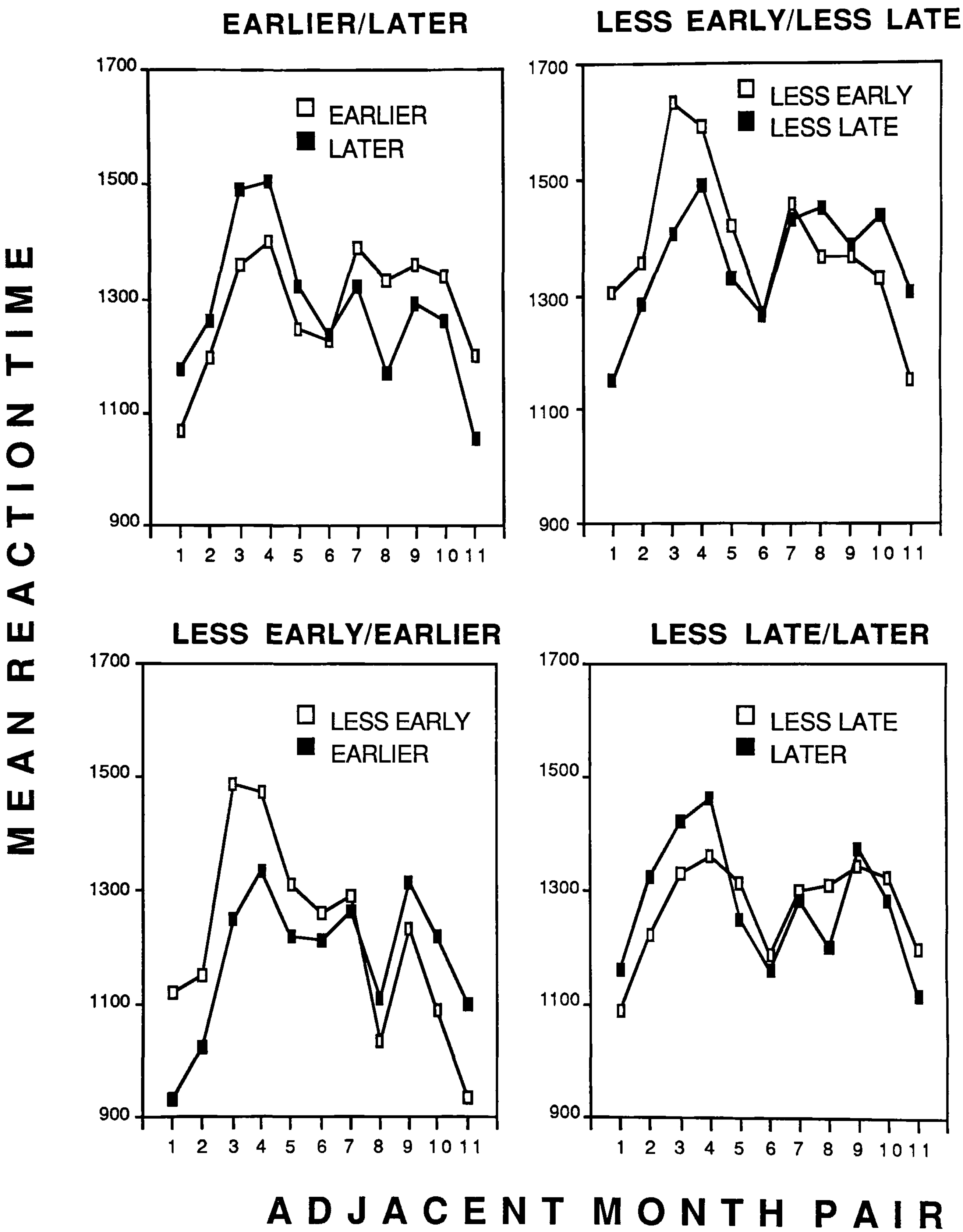

Figure 2.3 Semantic congruity effects obtained on mean latencies in conditions 1 (earlier/later, less early/earlier) and 2 (less early/less late, less late/later) of Experiments 1 and 2

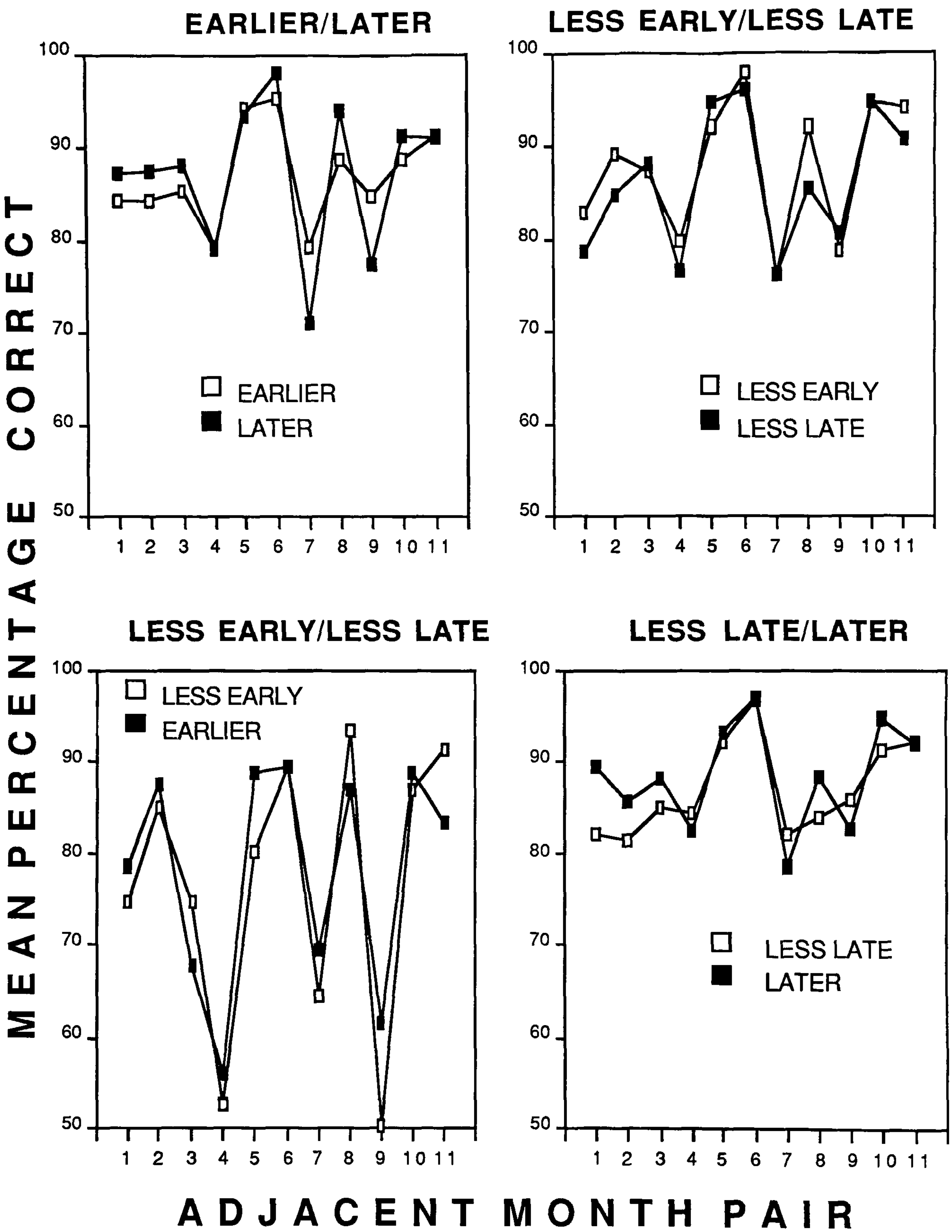

Figure 2.4 Semantic congruity effects obtained on mean percentages of correct responses in conditions 1 (earlier/later, less early/earlier) and 2 (less early/less late, less late/later) of Experiments 1 and 2

An analysis of variance performed with two within-subjects variables (month pair and polarity of the attribute in experiment 1; month pair and sign of the instruction in experiment 2) and one between-subjects variable (sign of the instruction in experiment 1; polarity of its attribute in experiment 2), confirmed the significance of the interaction of interest (i.e., Sign X Attribute X Month pair) on latency in both Experiments 1 and 2, $F(10,180)=18.78$, $p<.0001$; $F(10,180)=13.81$, $p<.0001$. Although this interaction was also significant on response accuracy, $F(10,180)=2.40$, $p<.011$; $F(10,180)=2.85$, $p<.003$, the percentage of correct responses did not vary consistently according to the position of the month pair in the month series relative to the polarity of the attribute of the instruction (see figure 2.12). The interaction on latency indicated that the form of the congruity effect differed for positive and negative instructions. The form of this effect for positive instructions, was determined by the polarity of the attribute of the instruction. Response latencies were shorter if the polarity of the attribute was congruent with the position of the stimulus pair in the month series than if it was not. Thus, early pairs were overall processed more rapidly with the attribute "early" than the attribute "late". Conversely, late pairs were overall processed more rapidly with the attribute "late" than the attribute "early". As for negative instructions, the form of this effect was, **in all conditions, the exact reversal of that obtained with positive instructions**. This finding is incompatible with the second and third recoding scenarios derived from Banks' semantic coding model and the second scenario derived from Holyoak's reference point model. Banks' scenario 2 predicted the presence of such a crossover congruity effect **only in Experiment 1**, if the stimulus recoding was of type 1, and the presence of funnel-shaped congruity effects in experiment 2. Furthermore, Banks' Scenario 3 and Holyoak's scenario 2 predicted the presence of a crossover effect with its form determined by the attribute of the comparative in Experiment 1, and the presence of parallel curves in Experiment 2. These predictions were refuted in the present research. The form of the congruity effect obtained with negative instructions indicates that subjects did not, when presented with a negative instruction, recode the stimulus pair into a negative form during the comparison stage or perform the comparison as if the instruction was positive and then switch response codes. The results are also inconsistent with Segui and Bertoncini's (1978) version of the recoding hypothesis; subjects did not recode the negative instructions only if the attribute was marked. Indeed, only Banks' and Holyoak's first scenarios are supported by these results. All negative instructions appear to have been recoded into their positive equivalent during the encoding stage. This recoding operation may be time consuming at the outset but it appears to become automatic with extended practice.

Conclusions

Three general conclusions may be drawn from the results of these two experiments. First, several characteristics of the stimuli, other than the symbolic distance and the congruity between the position of the pair in the month series and the polarity of the instruction's attribute, affected the difficulty of the overall decision process. Second, responses were slower to negative instructions than to positive instructions, but only on the first experimental session. Finally, the pattern of the semantic congruity effects obtained on latencies lend support to the idea that negative instructions are consistently recoded into their positive counterpart before the symbolic comparison is performed. We now turn to a more detailed discussion of the implications of the present results for the two general issues of this research, that is, the mental representation of the months of the year and the semantic interpretation of the comparative instruction.

The form of the symbolic distance and semantic congruity effects reported in the present experiments is overall consistent with Seymour (1980a, 1980b)'s boundary effects and Friedman (1983, 1984)'s proximity effects. As month pairs approached the boundary dividing the month series into two on the bipolar early/late continuum, overall comparisons were performed less rapidly and less accurately. Furthermore, the discontinuities noted in the distance and congruity functions about the June-July boundary lend support to Seymour's hypothesis of privileged access to adjacency information at some points in the month series. Access to adjacency information appeared to be very easy at the beginning, center and end of the series. This was clearly apparent in the plots that illustrated the semantic congruity effect.

Finally, although our results did not enable us to distinguish between an analogue and a discrete representation of the months of the year in the paired-comparison task, they lent support to the idea that our perception of the months of the year is not, in the present task, unidimensional. Groupings based on several stimulus characteristics occurred in the month series and these characteristics influenced the difficulty of the overall decision process. These characteristics were identified as being: 1) the symbolic distance between both members of the stimulus pair, 2) the length of month names, 3) the presence or absence of an end term in the month pair, and 4) the part of the year in which months fell (first vs. second part).

The results relevant to the semantic interpretation of the comparative instruction first show that negative instructions were more difficult to process than positive instructions only initially, on the first sessions. With extended practice, the sign of the comparative instruction no longer constituted a significant source of difficulty. The attribute of the instruction also did not seem to constitute, overall, an important source of difficulty in the decision process.

One very important finding of the present two experiments related to the form of the semantic congruity effect obtained on response latency with positive and negative instructions. The form of this effect differed for positive and negative instructions. For positive instructions, the form of the congruity effect was determined by the polarity of the attribute of the instruction. For negative instructions, the form of this effect was the exact reversal of that observed with positive instructions. This finding suggests that the strategy used to interpret negative instructions was to recode these statements into their positive equivalent before performing the comparison. This result is consistent with Huttenlocher and her collaborators (1970; 1971)'s version of the recoding hypothesis but not with that of Segui and Bertoncini (1978). All negative instructions appear to have been recoded into their positive equivalent, not only those that contained a marked adjective. This result is also compatible only with Banks' and Holyoak's first recoding scenarios. The rejection of Banks' scenarios 2 and 3 and of Holyoak's scenario 2 rule out the following two strategies as possible ways of interpreting negative instructions: 1) recode the stimulus pair during the comparison process, and 2) perform the comparison as if the instruction was positive and then switch response codes.

Finally, differences were noted in the sensitivity of both dependent variables to the difficulty of comparisons. The symbolic distance effects were less pronounced on accuracy than on latency, and congruity effects were observed only on latency. This result suggests that when subjects encountered difficult pairs, overall, they tended to slow themselves down in order to respond accurately. Note, however, that to have asked them to respond as rapidly and as accurately as possible, may have encouraged them to give more weight to response accuracy than to speed of response. The seeming dependence of the magnitude of the distance and congruity effects on the importance given to speed and accuracy of responses suggests one way of possibly distinguishing Banks' semantic coding model and Holyoak's reference point model, which could not be differentiated in the present experiments. Both models could now be evaluated by experimentally manipulating the requirements for fast vs. accurate decisions. The predictions of these two models concerning the effect of such a manipulation are examined in the next chapter.

CHAPTER III

SPEED/ACCURACY TRADEOFFS IN MENTAL COMPARISONS WITH THE MONTHS OF THE YEAR

One objective of Experiments 1 and 2 was to study the semantic interpretation of negative comparative instructions and thereby determine the strategy subjects used to perform the comparison task with such instructions. Two comparative judgment models, Banks' Semantic coding model and Holyoak's Reference point model, were extended to account for the interpretation of negative instructions. Different scenarios were developed in the context of both models. These scenarios depicted different types of instruction or stimulus recoding at different points in the overall decision process. A specific prediction was derived for each scenario concerning the form of the congruity effect obtained with negative instructions when either the sign or the attribute of the instruction was kept constant. Unfortunately, both models essentially did not make different predictions concerning the form of this effect and hence could not be contrasted.

SPECIFIC GOALS OF THE PRESENT EXPERIMENTS

The two experiments reported in this chapter had two main objectives. First, they were intended to extend the evaluation of Banks' semantic coding model and of Holyoak's reference point model. Second, they were intended to eliminate possible problems in the interpretation of the results of Experiments 1 and 2.

Concerning the first issue, Petrusic and Baranski (1989) suggested a way to evaluate Banks' and Holyoak's models. They studied the effect of the relative demands for speed vs. accuracy of responses on the magnitude of the semantic congruity effect. Banks' and Holyoak's models make different predictions concerning the effect of such a manipulation and thus could in this way be evaluated. The next two experiments were intended to serve as a confirmation or non-confirmation of Petrusic and Baranski's findings. These experiments, however, differed from those presented by Petrusic and Baranski in two respects: 1) the method used to manipulate the emphasis on speed vs. accuracy, and 2) the type of stimuli used. Petrusic and Baranski used verbal instructions to alter the emphasis on speed vs. accuracy in different conditions. We used a more systematic procedure, a deadline method in conjunction with a payoff matrix. Furthermore, they used perceptual stimuli while we used symbolic stimuli. This suggested a test of the generalizability of the results obtained with confusable perceptual stimuli and non-confusable symbolic stimuli.

As for the second issue, the conclusions that pertained to the interpretation of the comparative instruction in Experiments 1 and 2 were based solely on differences observed in mean response times or percentages of correct responses for different forms of this instruction. A distinction was not made between mnemonic and perceptual processes reflecting the interpretation of the comparative instruction and decisional processes reflecting the tradeoff between speed and accuracy of responses. Consequently, the differences noted in response times or percentages of correct responses for different forms of this instruction could partly reflect differences in speed/accuracy response criteria and not solely differences in processing difficulty. One other objective of the next two experiments thus was to separate the processes linked to the interpretation of the comparative instruction from those linked to the choice of a response criterion[6]. The conclusions that pertained to the interpretation of this instruction were now based on changes observed in the form of the function illustrating the tradeoff between speed and accuracy of responses (SAT) with different forms of this instruction.

The SAT function was generated in the present two experiments by systematically manipulating the requirements for fast vs. accurate decisions. The data obtained in Experiments 1 and 2 were also reanalysed by computing this function for each form of the comparative instruction. The results of this reanalysis will be presented just before those of Experiments 3 and 4. We now turn to a more detailed discussion of the two general issues of this chapter: 1) Effect of variations in the emphasis on speed and accuracy on the magnitude of the congruity effect and 2) A separation of mnemonic and perceptual processes from decisional processes: a study of the SAT function.

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[6] The intended meaning of the terms "response criterion", "decisional processes" and "mnemonic or perceptual processes" is as that found in the signal detection theory. Mnemonic or perceptual processes refer to the processes by which the comparative instruction is encoded and processed. A measure of the level of difficulty of interpretation of this instruction can be obtained. Decisional processes refer to the predisposition of subjects to respond liberally (rapidly) or conservatively (accurately) independently of the interpretability of the instruction. Finally, the response criterion refers to a cutoff for a given decision. This cutoff may correspond to the amount of evidence accumulated in favor of a given response, required to trigger this response. This specific amount will vary according to subjects' predisposition to respond liberally or conservatively.

EFFECT OF VARIATIONS IN THE EMPHASIS ON SPEED AND ACCURACY ON THE MAGNITUDE OF THE CONGRUITY EFFECT

Petrusic and Baranski (1989) classified different comparative judgment models into three categories according to the locus of the semantic congruity effect in the overall comparison process. Models were categorized as postulating either a: 1) pre-decisional, 2) decisional or, 3) post-decisional locus of the semantic congruity effect. One example of a model classified as "pre-decisional" is the expectancy model (Kosslyn, Murphy, Bemesderfer, & Feinstein, 1977; Marschark & Paivio, 1979; 1981; Moyer & Dumais, 1978; Shipley, Norris & Roberts, 1946). Briefly, according to this model, the form of the comparative instruction prepares subjects for a range of stimuli located at positions on the underlying continuum that are congruent with the polarity of this instruction's attribute. If the position of the stimuli is in fact congruent with the polarity of the instruction's attribute, a response can be given immediately. If this is not the case, additional time is required to correct the initial false expectation and thereby accurately process the presented stimuli. This is what gives rise to the congruity effect. Next, an example of a model classified as "post-decisional" is Banks' semantic coding model. As mentioned in Chapter 1, the congruity effect in this model occurs as a consequence of stimulus and instructional code matches or mis-matches. The effect has, according to Petrusic and Baranski, a post-decisional locus since the code translation operation, which accounts for this effect, occurs after the creation of discriminable stimulus codes.

One example of a model classified as having a decisional locus of the congruity effect is Jamieson and Petrusic's 1975 discrepancy ratio model further elaborated by Holyoak (1978) as the reference point model. According to this model, the comparative instruction activates, as mentioned in Chapter 1, a reference point. This reference point is then used to perform the comparison. The distance from each stimulus analogical representation to this reference point is computed. Both derived distances are then compared by obtaining a ratio of the smallest difference on the largest. This comparison process is in Holyoak's model embedded in a simple random walk model similar to that described by Buckley and Gillman (1974). Subjects thus perform multiple internal comparisons of both derived distances. An accumulator is set to zero at the beginning of each trial, and after each successive comparison of both distances, a value proportional to the quantity log(distance 1) log(distance 2) is added to the accumulator. This accumulator is incremented after each additional comparison until it reaches either a positive or negative criterion. Subjects then respond by selecting the left or right member of the stimulus pair. The congruity effect arises because, as the stimulus pair approaches the reference point, the value of the discrepancy ratio decreases and the time required to reach the correct criterion also decreases. Inversely, as the distance between the stimulus pair and the reference point increases, the value of this ratio increases as well as the time required to reach the correct criterion.

Petrusic and Baranski's classification of the comparative judgment models suggested a way of evaluating these different models. Two variables known to influence the duration of the decision process were manipulated. They were: 1) the relative demands for speed vs. accuracy of responses and 2) the decision difficulty, that is, the stimulus discriminability. The effect of such manipulations on the magnitude of the congruity effect was then examined. Petrusic and Baranski reasoned that if the semantic congruity effect has a decisional locus, its magnitude will systematically be affected by these manipulations. Inversely, if the effect has a pre- or post-decisional locus, its magnitude will be unaffected by these manipulations. Furthermore, if the magnitude of the congruity effect is found to be affected by these manipulations, all pre- (e.g., expectancy model) and post-decisional models (e.g., Banks' semantic coding model) will be refuted. Inversely, if the magnitude of this effect is found to be unaffected by these manipulations, all decisional models (e.g. Holyoak's reference point model) will be disconfirmed. In what follows, only the effects of the relative demands for speed and accuracy have been investigated.

Petrusic and Baranski (1989) manipulated the relative demands for speed vs. accuracy of responses only in the first of three experiments, by means of verbal instructions. One group of subjects was instructed to sacrifice speed for accuracy while another was instructed to sacrifice accuracy for speed. Overall, the results of this experiment indicated first that the congruity effect on response latencies tended to be more pronounced for accuracy-instructed than for speed-instructed subjects. This dependence of the congruity effect's magnitude on the relative demands for speed vs. accuracy implies a decisional locus for the effect and consequently lends support to Holyoak's reference point model. Furthermore, this finding is, by this account, inconsistent with the expectancy and semantic coding models as currently formulated. Second, another very important result obtained consisted in a dissociation between the accuracy and response time based measures of the congruity effect. A congruity effect was not observed on response accuracy, even though pairs imperfectly discriminated with a substantial error rate were present in the stimulus sets. This result is, as pointed out by Petrusic and Baranski, problematic for all models and especially for decisional models, which had formulated clear predictions on this issue. Holyoak's reference point model, for instance, assumed that both response time and accuracy were monotonic functions of the difference between the decisional criterion and the discrepancy ratio. Thus, a congruity effect was predicted on both response measures. One possible explanation of this surprising dissociation between both response measures might be, as suggested by Petrusic and Baranski, that response times and percentages of correct responses differ considerably in their sensitivity to decision difficulty. Petrusic and Jamieson (1979), for instance, have shown that response times continue to be sensitive to relations on stimulus pairs well after percentages of correct responses have become insensitive to such variations.

Finally, Petrusic and Baranski (1989) also examined (in Experiment 3) the relation between the magnitude of the congruity effect on response times for correct vs. incorrect responses. This examination permitted another test of the different comparative judgment models and more specifically of Banks' and Holyoak's models. The prediction of Banks' semantic coding model in this specific context was that of overall less pronounced congruity effects for incorrect than for correct responses. This prediction stemmed from the fact that in this model the code translation was assumed to represent a constant time increment. Furthermore, errors were assumed to occur mainly as a consequence of the failure to translate codes and thereby were expected to reduce the overall magnitude of the congruity effect. On the other hand, Holyoak's reference point model, with its simple random walk mechanism, predicted congruity effects of equal magnitude for correct and incorrect responses. This prediction follows because, in this case, the probability of selecting the correct response is independent of the duration of the random walk. Thus, any random walk reaching a given critical value has the same probability of being correct as any other walk also reaching this value.

The relative demands for speed vs. accuracy were not manipulated in this experiment. Subjects were asked to be as accurate as possible while not taking too much time to respond. Overall, the results indicated that error times were larger than correct times and that the congruity effect was more pronounced for error than for correct times. These results are clearly inconsistent with both Bank's and Holyoak's models. Petrusic and Baranski nonetheless concluded that on balance, the results obtained in their three experiments tended to favour the reference point model over the semantic coding model. Thus, less modifications would be required on Holyoak's than on Banks' model to provide a full account of Petrusic and Baranski's findings. They suggested that an evidence accrual model other than the simple random walk model should be implemented in Holyoak's reference point model.

The two experiments reported in this chapter were intended to extend Petrusic and Baranski's 1989 work on the effect of the relative demands for speed vs. accuracy of responses on the magnitude of the congruity effect. These demands were manipulated by means of a deadline method in conjunction with a payoff matrix, rather than by means of verbal instructions. By this method, three different contexts of emphasis on speed vs. accuracy were created: 1) a context of extreme speed emphasis (deadline block 1), 2) a context of moderate speed emphasis (deadline block 2) and 3) a context of extreme accuracy emphasis (deadline block 3). We were also interested in comparing the magnitude of the congruity effect for response times of correct vs. incorrect responses in each of these three contexts. Petrusic and Baranski's (1989) findings led us to expect larger congruity effects for incorrect than for correct responses and that as the emphasis on accuracy of response would increase, the difference in the magnitude of this effect for incorrect vs. correct responses would also increase. Finally, we were also very much interested in determining if response accuracy is really, as Petrusic and Baranski's results seemed to indicate, less sensitive to decision difficulty than speed of response. The results obtained in our first two experiments were consistent with this hypothesis: a congruity effect was observed only on response times. A more systematic manipulation of the emphasis put on speed vs. accuracy of responses may increase the sensitivity of response accuracy to decision difficulty and consequently the probability of it displaying a congruity effect.

A SEPARATION OF MNEMONIC AND PERCEPTUAL PROCESSES FROM DECISIONAL PROCESSES: A STUDY OF THE SAT FUNCTION

One feature common to most mental comparison studies, and in general most conventional reaction time studies, is that subjects are asked to make their decisions as rapidly and as accurately as possible. Another feature common to most of these studies is the consideration of only one dependent variable: response times. Error rates are often very low and thus are considered as unimportant. They are viewed as being part of a normal variability inherent to the performance of subjects and, consequently, are ignored. Another fairly common practice is to eliminate response times of incorrect responses, or any other response time (very fast or slow responses) which appears to be in contradiction with the general definition of response times. According to this definition, response times are obtained under conditions in which subjects try to minimize their response times, while being accurate. Reaction time is thus the minimum time required for subjects to produce a correct response. Such a definition clearly makes strong assumptions concerning subjects' intentions. In practice their performance never matches this definition. Several researchers see this as a problem and thereby report on only the portion of their original latency data that seems to conform to the requirements of this definition. Pachella (1974) and Wickelgren (1977) have shown that such editing of experimental data is not justified.

We now examine briefly some problems inherent to such practices. First, the assumption that low error rates are unimportant and consequently that their elimination is inconsequential is untenable and can lead to serious errors of interpretation. In most conventional response time studies, the task is very simple and subjects would probably never make errors if they were not timed. The low error rates are a consequence of their tendency to respond a little faster than they should in order to minimize their response times. With the typical instructions given to them (i.e., respond as rapidly and as accurately as possible), subjects must find the optimal speed with which to work. They must find

> "a compromise between the incompatible demands for maximum accuracy and minimum RT" (Wood and Jennings, 1976; p.92).

Subjects thus choose a response criterion by which they will rush their responses to the extent of occasionally making an error, and this within a range they feel is acceptable.

The fact that subjects do not operate at a point of maximal accuracy, that is, the fact that they make errors, is not in itself problematic. What is problematic is the possibility that subjects vary from one condition to the other their predisposition to rush their responses. The response criteria adopted may differ from one condition to the other. This problem is very important since differences in response criterion may be correlated with the experimental manipulations of interest. Response time differences between two or several levels of a variable then may not reflect solely differences in processing difficulty. This possibility is even more important when the error rates are ignored because response time differences reported as statistically significant may in fact be artifactual. A similar problem was also noted in the context of studies dealing with the detection of weak signals (Green and Swets, 1966). The predisposition of people to say "yes I detect a signal" or "no I do not detect a signal" was found to vary considerably from one person to the other. Thus, the thresholds of detectability greatly differed from one person to the other, even though several of these persons were equally sensitive to the stimuli.

A solution proposed to the problem of "variable response criteria", is to pay special attention to the relationship between speed and accuracy of responses. This relationship is to be examined over a wide range of different response criteria by asking subjects to work at various speed rates in different blocks of trials. The function relating response time to accuracy, the speed-accuracy tradeoff (SAT) function, is then drawn for each level of the independent variable of interest. Conclusions concerning the effect of this variable are based on changes observed in the overall form of this function at different levels of this variable. A similar approach is also used in signal detection theory.

> "The functional relation between hit rate and false-alarm rate, the receiver operating characteristic (ROC), is used as the decision-free measure of detection, rather than any specific value of hit rate or false-alarm rate" (Lappin and Disch, 1972; p. 420).

Changes may be observed on three parameters of the SAT function: 1) its intercept on the x-axis, corresponding to the time at which accuracy begins to rise above chance; 2) its slope, corresponding to the rate of increase of accuracy as a function of response time and 3) its asymptote on the y-axis, corresponding to the point at which accuracy stops increasing.

Figure 3.1 illustrates an idealized SAT function. This function is monotonically increasing, and when accuracy is measured in terms of the proportion of correct responses, it is negatively accelerated indicating that small differences in error rates at high levels of accuracy can lead to large differences in response times. Because of this particular characteristic of the SAT function, having subjects be very cautious and produce very few errors is not recommendable. As Pachella (1974) pointed out, seemingly meaningless differences in error rates may reflect important differences in response criteria and thereby greatly contaminate response time values.

Different methods can be used in order to make subjects work at various speed rates, and thereby study the relationship between speed and accuracy over a wide range of response criteria. The most commonly used methods are: 1) verbal instructions (e.g., Hick, 1952; Howell and Kreidler, 1963; 1964; Hale, 1969; Petrusic and Baranski, 1989), 2) Payoff matrices (e.g., Fitts, 1966; Swenson, 1972; Swenson and Edwards, 1971), 3) deadline methods (e.g., Pachella, Fisher and Karsh, 1968; Pachella and Fisher, 1969; 1972; Link and Tindall,1971; Link, 1971; Jennings, Wood and Lawrence, 1976; Grice, Spiker and Nulmeyer, 1979), 4) deadline methods in conjunction with payoff matrices (e.g., Ollman, 1966; Pew, 1969; Yellot, 1971), 5) time bands (e.g., Snodgrass, Luce and Galanter, 1967; Green, Smith and Gierke, 1983) and, 6) signal response methods (e.g., Schouten and Bekker, 1967; Reed, 1973; 1976; Vickers, Burt, Smith and Brown, 1985).

Another method can also be used to generate SAT functions in experiments in which the requirements for fast and accurate decisions are not manipulated (e.g., Schouten and Bekker, 1.967; Rabbit and Vyas, 1970; Lappin and Disch, 1972). The

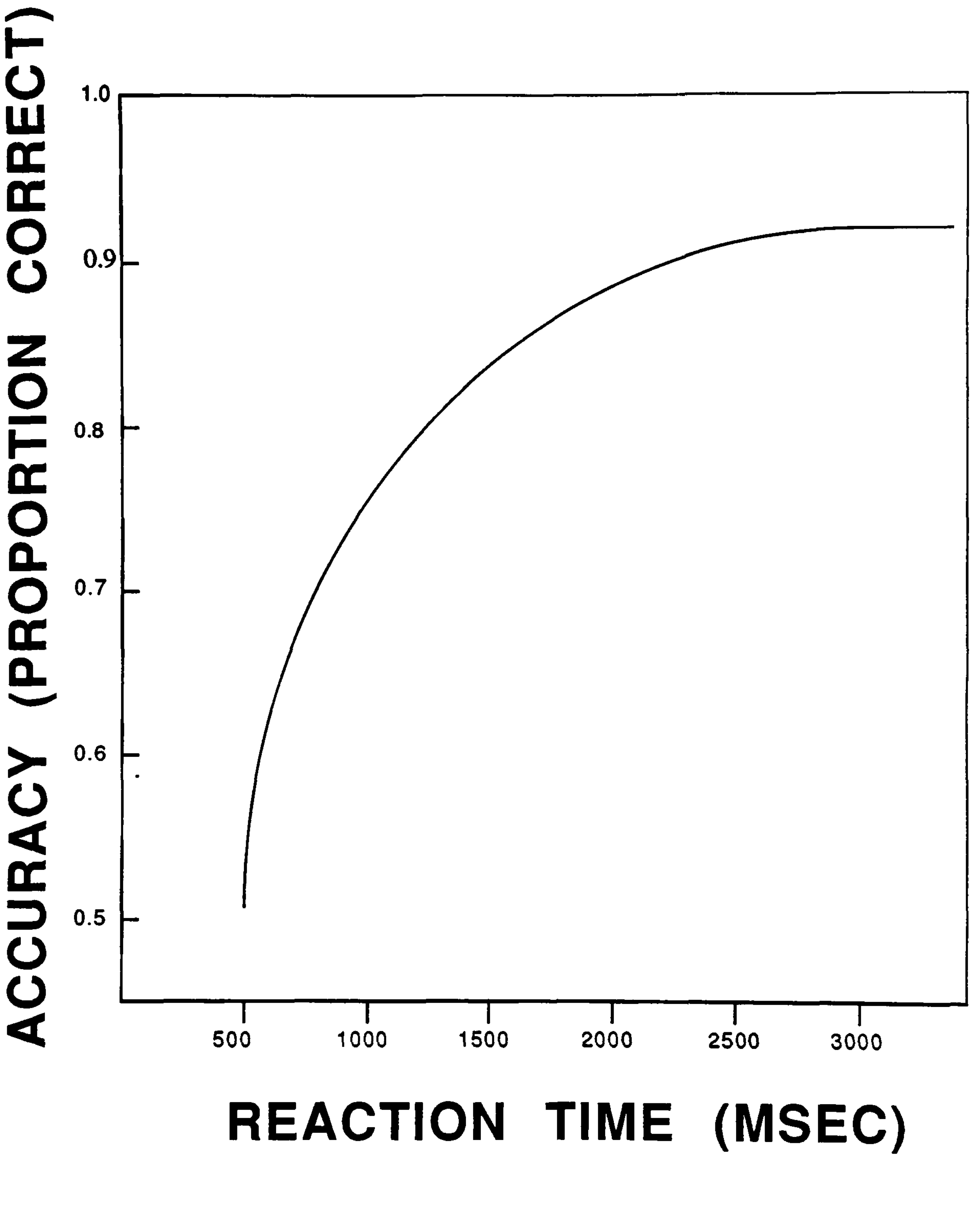

Figure 3.1 An idealized speed-accuracy tradeoff function

obtained response times are first ranked from fastest to slowest. This distribution is then partitioned into a certain number of categories (e.g., 7) with an equal number of responses in each category. The mean response time and corresponding mean percentage of correct responses in each of these categories can then be plotted one against the other. This method can also be used in an experiment in which the emphasis on speed or accuracy is directly manipulated. Instead of computing the overall mean response time and percentage of correct responses for each speed emphasis block of trials, the response time distribution in each of these blocks of trials can be partitioned as described above.

The SAT functions generated by reanalysing the data of Experiments 1 and 2 were drawn by means of the method just outlined. A SAT function was also drawn in each of the three deadline blocks of Experimênts 3 and 4 by means of this method. The response time distribution obtained in each deadline block was partitioned into eight categories. An examination of the form of the SAT function obtained in each deadline block for each form of the comparative instruction enabled a more adequate interpretation of the effect of the sign and of the adjective of the instruction on the overall decision process. Ideally, what was seeked was a measure of the processing difficulty of the different forms of the comparative instruction, free of bias resulting from possible variations in subjects' predispositions to rush their responses.

Pachella (1974) suggested that variables affecting different processing stages in a choice response time task would alter the form of the SAT function in different ways. Variables affecting the stimulus encoding stage, such as stimulus degradation, would only add a constant to the time needed to attain a level of accuracy above chance. Such variables would only affect the value of the intercept on the x-axis. Inversely, variables affecting the comparison stage such as stimulus discriminability would alter the rate at which speed is traded for accuracy. These variables would affect only the slope of the SAT function. Other variables could also affect the point at which maximal accuracy is reached, that is, the asymptote of the SAT function. Although these hypotheses may well be much too simplistic, they permitted clear predictions concerning the effect of the sign of the comparative instruction on the overall form of the SAT function. If, as the data obtained in Experiments 1 and 2 suggested, negative instructions are recoded into their positive equivalent during the encoding stage and that this recoding operation significantly increases the difficulty of the overall decision process, significant differences in the value of the SAT function's intercept on the x-axis should be observed for positive and negative instructions. The value of this parameter should be smaller for positive than for negative instructions. This specific prediction was evaluated.

Finally, Pachella (1974) identified two types of SAT functions, a macro and a micro SAT function. The first type of tradeoff is the one which has just been described. It concerns the average speed and accuracy of responses for various speed-emphasis conditions. The micro tradeoff concerns the relation between the speed of correct and incorrect responses in a particular speed emphasis condition[7]. An examination of the relation between response times of correct and incorrect responses in each deadline block enabled a test of three different theoretical models of the SAT: 1) Yellot's 1971 fast guess model, 2) the simple random walk model (e.g., Stone, 1960; Laming, 1968) and, 3) the accumulator model (e.g., Vickers, 1970; 1979). All three models agree on the general form of the macro SAT function. They all predict that as more emphasis is put on speed than on accuracy of responses, both response times and percentages of correct responses will decrease. Inversely, as more emphasis is put on accuracy than on speed of responses, both response times and percentages of correct responses will increase. However, these models disagree on the general form of the

[7] The term "micro SAT" has also been used in two other contexts to designate the type of SAT function generated: 1) in experiments in which the emphasis on speed vs. accuracy was not manipulated but in which the obtained response time distribution was partitioned into n categories and 2) in different speed emphasis conditions in which the response time distribution was also partitioned into n categories.

micro SAT function. In what follows, each of these three models will be outlined as well as their predictions concerning the overall form of the macro and micro SATs.

According to Yellot's Fast-Guess model, two types of responses can be made in conditions emphasizing speed of responses, stimulus-controlled and fast-guess responses. Stimulus-controlled responses are necessarily correct since in these cases subjects take the time necessary to produce a correct response. Conversely, fast-guess responses are much faster and have only a chance probability of being correct since in these cases, the stimuli are not processed at all. As the emphasis on speed increases, the percentage of fast-guess responses also increases. Consequently, both mean response times and percentages of correct responses decrease. This model predicts **faster incorrect than correct responses** since in this context errors can arise only as a consequence of the presence of fast-guess responses while correct responses constitute a mix of fast-guess responses correct by chance and of stimulus-controlled responses.

The other two models, the simple random walk and accumulator models, are classified as "accumulative". Both models assume that responses are contingent upon a decision process based on the accumulation of evidence for each possible response. The evidence accumulated in both models is probabilistic and thus fallible. Subjects respond when the pressures for speed demand it on the basis of partial information accumulated thus far. The way in which evidence is accumulated differs in both models.

Evidence is, in the accumulator model, accumulated separately for each response. Thus, one piece of information favouring one response does not affect the state of evidence for the other response. A decision is made when the evidence favouring one of the responses exceeds a given criterion. In the random walk model, the decision made is based on a relative rather than an absolute criterion. One piece of information favouring one response affects the state of evidence for both responses, increasing the chances for one response and decreasing those for the other. When the evidence favouring one response exceeds that favouring the other by a critical amount, a decision is made. Both models predict that as the value of the response criterion increases, the amount of evidence required to make a decision also increases and consequently, mean response times and percentages of correct responses as well. Furthermore, as the emphasis put on speed increases, the value of this criterion decreases and, consequently, so do mean response times and percentages of correct responses. However, both models make different predictions concerning the relation between the response times of correct and incorrect responses. The accumulator model predicts **slower incorrect than correct responses** since in this context, errors tend to be associated with longer sequences of evidence than correct responses. The random model predicts, as mentioned earlier, **equal times for incorrect and correct responses** since in this context the probability of giving a correct response is independent of the duration of the random walk. Any random walk reaching a given critical value has the same probability of being correct as any other walk also reaching this value.

The above predictions as well as those pertaining to the effect of variations in the emphasis put on speed vs. accuracy of responses on the overall form of the congruity effect were evaluated in the next two experiments.

EXPERIMENTS 3 AND 4

Method

Subjects

Sixteen undergraduate students enroled in a Psychology introductory course at the University of Ottawa served as paid volunteer subjects. Each experiment involved two conditions with four subjects randomly assigned to each condition. All subjects were, as in the first two experiments, native speakers of French and had not participated in a symbolic comparison experiment previously. They received an initial 40$ for completing ten one-hour sessions and could earn another 40$ according to their performance.

Material and equipment

The materials included all possible adjacent month pairs (22 pairs) and the four forms of the French comparative for time order: PLUS TOT "earlier", PLUS TARD "later", MOINS TOT "less early", and MOINS TARD "less late". Each instruction appeared horizontally near the centre of an AMDEK 310A video monitor, and both members of the stimulus pair were shown slightly below, one on each side of the instruction. Timing, sequencing, presentation of instructions and stimuli, and recording of responses and response times were controlled by an IBM XT microcomputer. Subjects were seated in front of a table which supported the video monitor and a PC systems mouse.

Procedure

Subjects were tested individually in a quiet room. They were asked to press the key of the mouse to the side of the month that matched the displayed instruction. Requirements for fast and accurate decisions were manipulated by means of a deadline method in conjunction with a payoff matrix in three different contexts. In each context, subjects were instructed to make their response within a fixed time interval while being as accurate as possible. Subjects were asked to respond in less than 700 msec. in the first context, in less than 1000 msec in the second context (1100 in condition 2 of experiment 3) and in less than 2000 (experiment 3) or 2500 msec. (experiment 4) in the third context. The deadlines were chosen on the basis of results obtained with pilot subjects and results obtained in the previous two experiments. Deadlines were chosen so that roughly 60% correct responses be obtained in the first context, 80% correct responses in the second context and 100% correct responses in the last context. The payoff matrix was as follows: One point was allocated for response given before the deadline in the first two contexts, while .05 and .08 point were taken off for each incorrect response in the first and second context, respectively. In the last context, one point was allocated for each correct response and 0.8 point was taken off for each response given after the deadline. The points earned were then converted into a contingent monetary reward.

Subjects also were instructed, as in the two first experiments, to think of the months of the year as a linear series spanning from January to December. Furthermore, they were reminded at the beginning of each session of the requirements for fast and accurate decisions and were told that their goal should be to try to earn as much money as possible.

Both experiments involved ten sessions of 284 self-paced trials each. These 284 trials included: (a) 20 practice trials, and (b) two blocks of 44 experimental trials in each deadline context (i.e., 11 adjacent month pairs X 2 left-right presentation orders X 2 comparative instructions) for a total of six blocks of trials. Subjects were instructed to take a short break between each of the six blocks of experimental trials. Each trial consisted of the following sequence of events: a) A fixation point (plus sign) appeared near the center of the video monitor and remained visible for 500 msec; b) The screen was blanked and remained so for 500 msec, c) An instruction and a stimulus pair appeared simultaneously and remained in view until the subject made a response; d) subjects pressed the left or right key of the PC mouse to indicate their choice; e) the screen again was blanked and remained so for 500 msec, f) a message then was presented for 2000 msec indicating whether the response was correct or not (correct response vs. incorrect response); g) a second message was displayed 500 msec later indicating whether the response had met the deadline or not (speed ok vs. speed to slow); and finally h) a last message was shown to remind subjects to press any key of the PC mouse in order to initiate the next trial. The order of trials was random and this random order differed on each block and for every participant in the experiment. Subjects were also told before each block of trials what would be the deadline in effect for this block.

Results and discussion

The results obtained in both experiments are presented under two sub-headings, namely, 1) the effect of variations in the emphasis put on speed and accuracy on the magnitude of the congruity effect and 2) a separation of mnemonic and perceptual processes from decisional processes: a study of the SAT function. Two aspects of subjects' performance were examined: 1) response times and 2) response accuracy. The dependent variables for all analyses carried out were overall mean response times in msec and mean percentages of correct responses. Mean response times of correct and incorrect responses were also, for some of these analyses, distinguished.

EFFECT OF VARIATIONS IN THE EMPHASIS ON SPEED AND ACCURACY ON THE MAGNITUDE OF THE CONGRUITY EFFECT

In order to examine the effect of variations in the emphasis put on speed and accuracy on the magnitude of the semantic congruity effect, the mean response time and mean percentage of correct responses for each adjacent month pair in each deadline block were plotted separately for each of the two presented comparative instructions. These data were averaged over blocks of trials, presentation order of the stimuli, sessions, and subjects. Figures 3.2 to 3.4 and 3.5 to 3.7 illustrate this effect for each deadline block on response latency and accuracy, respectively.

A response time congruity effect was readily visible in each deadline block of only conditions 1 ("less early/earlier") and 2 ("less late/later") of Experiment 4. A congruity effect was also apparent on response accuracy in some conditions, although not in all deadline blocks. This effect was manifest in the second deadline block of condition 2 of Experiment 3 ("less early/less late") and conditions 1 and 2 of Experiment 4, and in the first deadline block of condition 2 of Experiment 3. An examination of these plots also suggested that the magnitude of the congruity effect was affected by the relative demands for speed and accuracy of responses only in Experiment 4: The congruity effect was more pronounced on latency when more emphasis was put on accuracy than on speed of response. On accuracy, it was more pronounced in a context of moderate speed emphasis than in one of extreme speed or extreme accuracy emphasis.

In order to assess the validity of the above observations, an analysis of variance was performed on each dependent variable with three repeated measures (month pair, deadline block, and polarity of the attribute in Experiment 3; month pair, deadline block, and sign of the instruction in Experiment 4) and one between-subjects factor (sign of the instruction in Experiment 3; polarity of its attribute in Experiment 4).

The analyses carried out in Experiment 3 yielded seven marginally or statistically significant effects on latencies and five statistically significant effects on accuracy: a) latencies and percentages of correct responses increased from deadline blocks 1 to 3 (495 to 796 to 1187 msec; .57 to .75 to .93 correct), $F(2,12)=57.71$, $p<.0001$; $F(2,12)=56.26$, $p<.0001$; b) responses to negative instructions were globally slower than those to positive instructions (877 vs. 775 msec), $F(1,6)=5.38$, $p<.059$; c) However, when examining each deadline block separately, the difference between positive and negative instructions was significant only on the third block, $F(1,6)=9.30$, $p<.023$; d) responses to instructions containing the adjective "late" were slower than those to instructions containing the adjective "early" (833 vs 819 msec), $F(1,6)=4.40$,

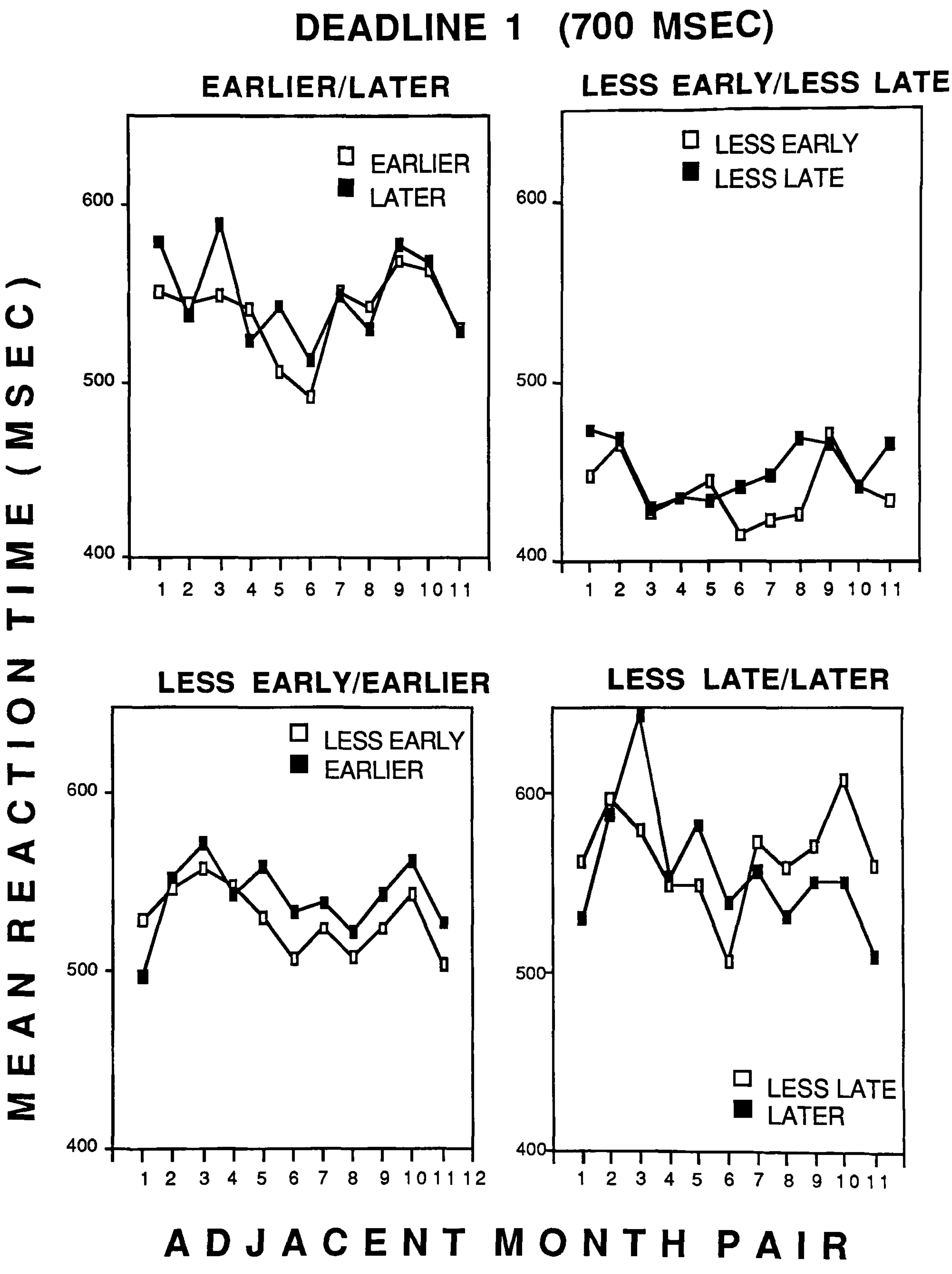

Figure 3.2 Semantic congruity effects obtained on mean latency in deadline block 1 of conditions 1(earlier/later, less early/earlier) and 2 (less early/less late, less late/later) of Experiments 3 and 4

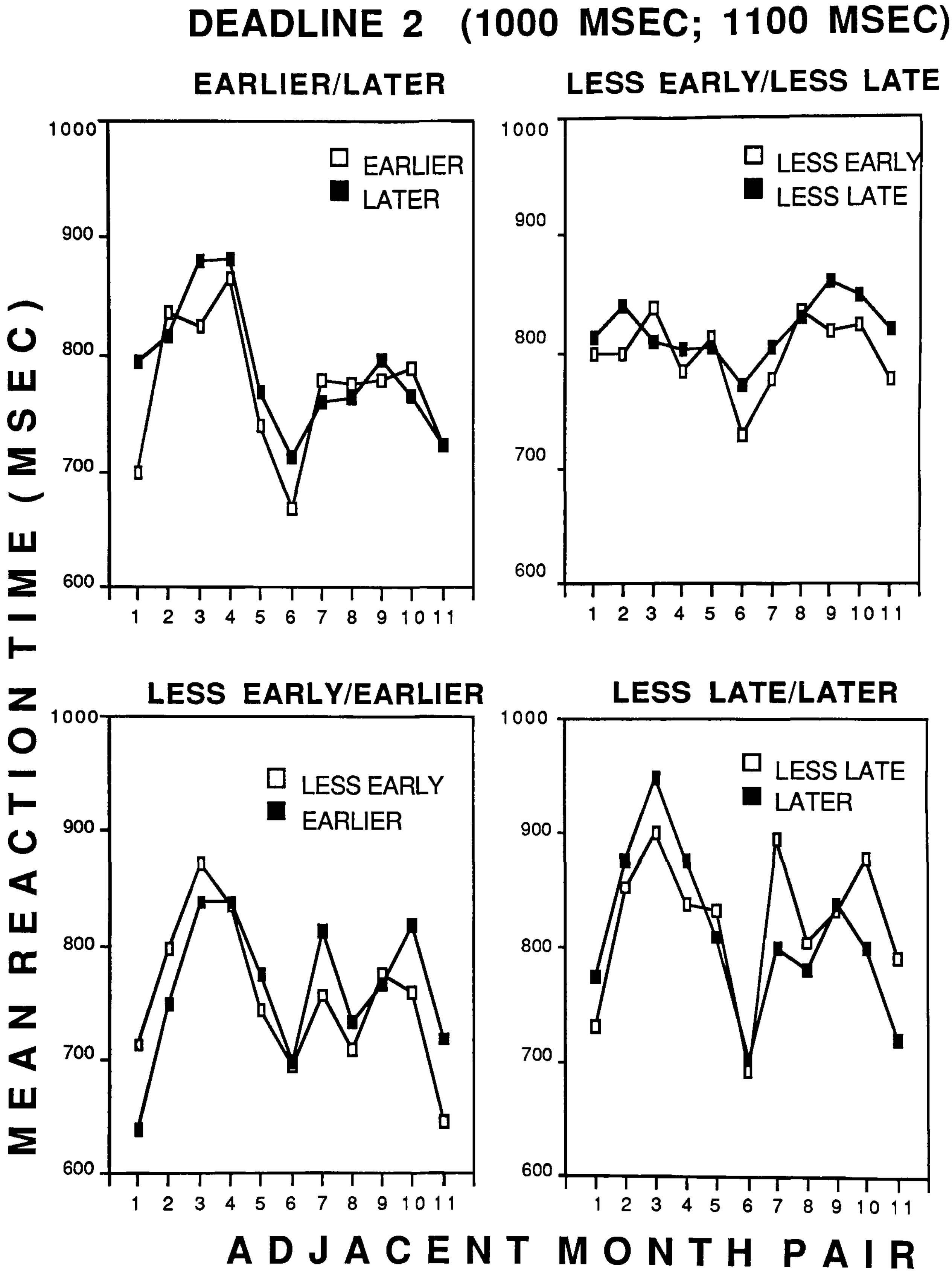

Figure 3.3 Semantic congruity effects obtained on mean latency in deadline block 2 in conditions 1(earlier/later, less early/earlier) and 2 (less early/less late, less late/later) of Experiments 3 and 4.

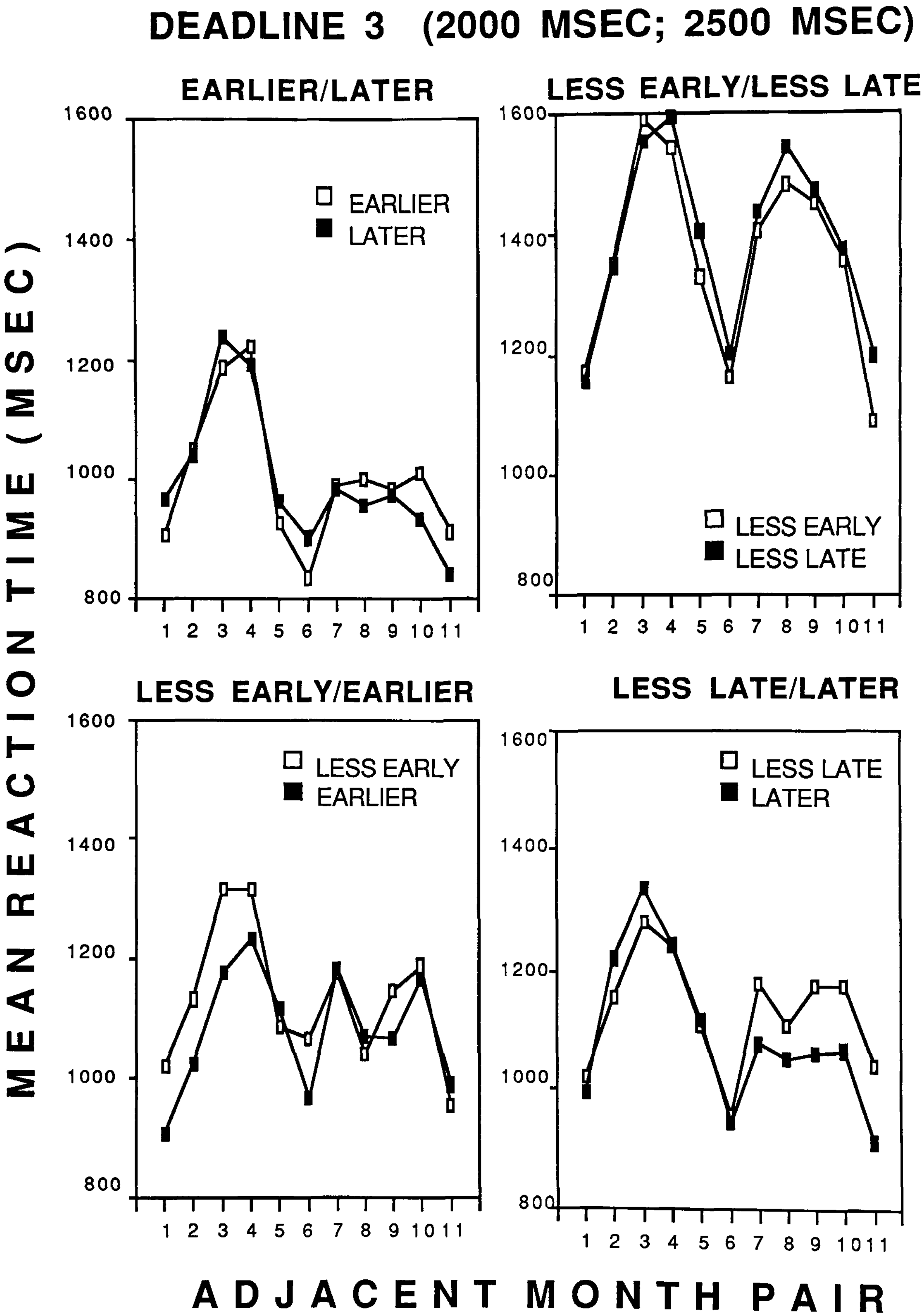

Figure 3.4 Semantic congruity effects obtained on mean latency in deadline block 3 of conditions 1(earlier/later, less early/earlier) and 2 (less early/less late, less late/later) of Experiments 3 and 4

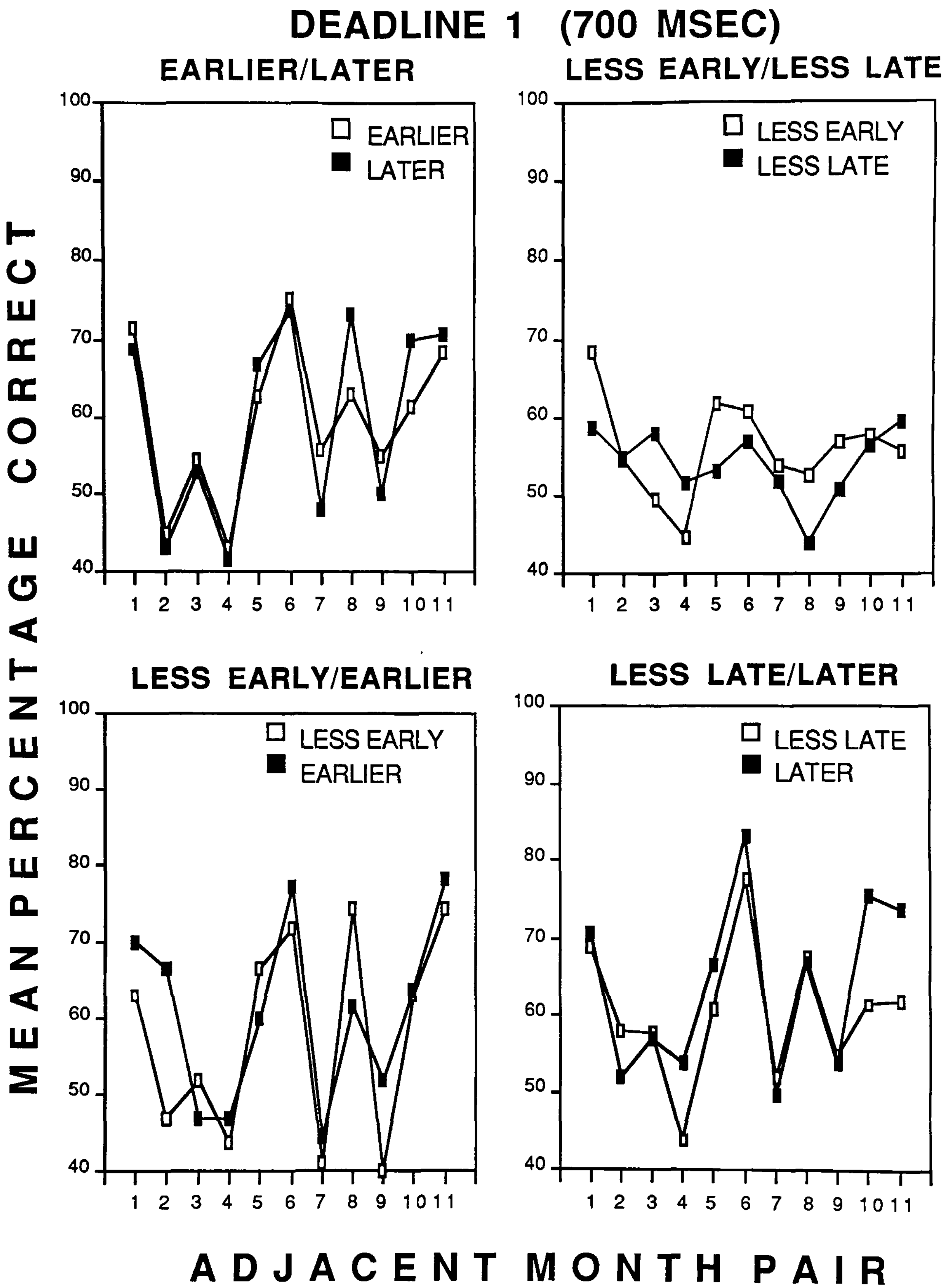

Figure 3.5 Semantic congruity effects obtained on mean percentages of correct responses in deadline block 1 of conditions 1(earlier/later, less early/earlier) and 2 (less early/less late, less late/later) of Experiments 3 and 4

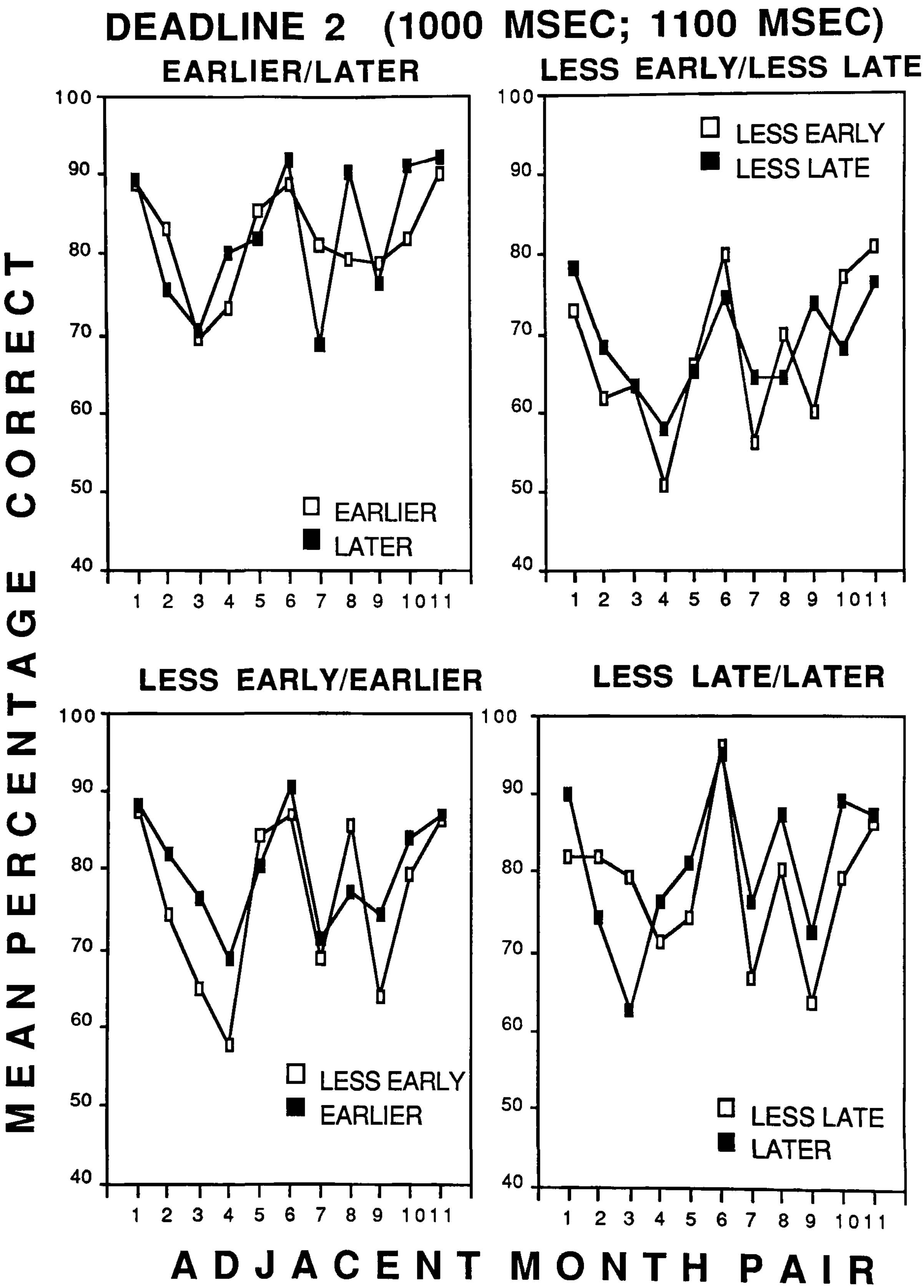

Figure 3.6 Semantic congruity effects obtained on mean percentages of correct responses in deadline block 2 of conditions 1 (earlier/later, less early/earlier) and 2 (less early/less late, less late/later) of Experiments 3 and 4

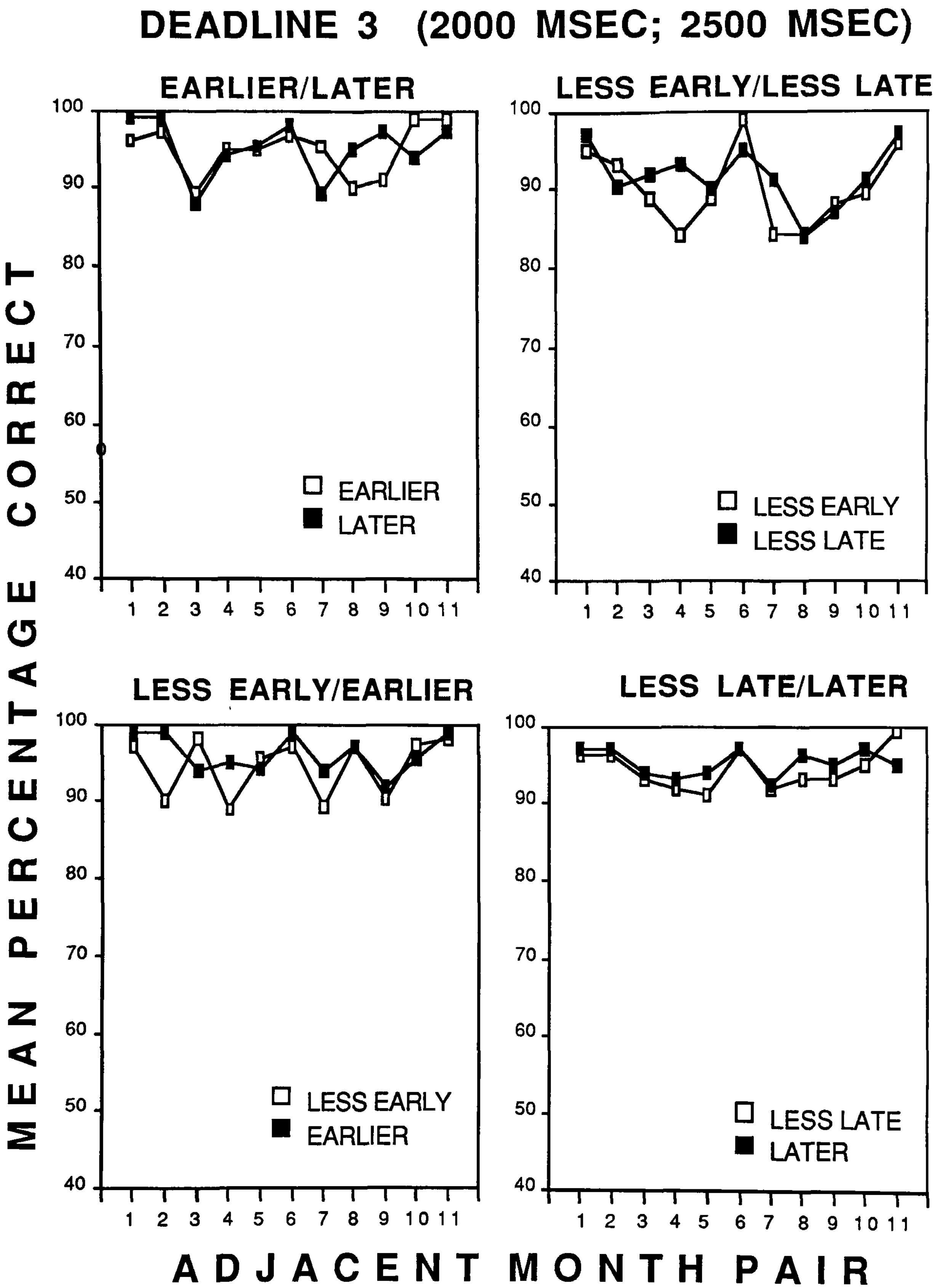

Figure 3.7 Semantic congruity effects obtained on mean percentages of correct responses in deadline block 3 of conditions 1 (earlier/later, less early/earlier) and 2 (less early/less late, less late/later) of Experiments 3 and 4

$p<.08$; e) all 11 adjacent month pairs did not, as expected, yield equal response times and percentages of correct responses, $F(10,60)=7.07$, $p<.0001$; $F(10,60)=7.83, p<.0001$; f) Although this effect of pairs was detected in each deadline block, the amplitude of the variations increased from deadline blocks 1 to 3 for latencies and decreased from deadline blocks 1 to 3 for accuracy, $F(20,120)=5.41$, $p<.0001$; $F(20,120)=3.64$, $p<.0001$; g) a global congruity effect (Attribute X Pair interaction) was present on latencies only in condition 1 ("earlier/later"), $F(10,60)=2.66$, $p<.009$; h) a Sign X Pair interaction was detected on accuracy only at deadline block 1, $F(10,60)=3.48$, $p<.001$; and finally i) the Deadline by Sign by Attribute by Pair interaction was significant on accuracy, $F(20,120)=1.70$, $p<.042$, confirming the occurrence of a congruity effect on accuracy only in condition 2 ("less early/less late") in deadline block 2, $F(10,60)=1.85$, $p<.07$.

The same analyses performed on the data obtained in Experiment 4 yielded six marginally or statistically significant effects on latencies and six statistically significant effects on accuracy: a) latencies and percentages of correct responses increased from deadline blocks 1 to 3 (549 to 788 to 1108 msec; .61 to .79 to .95 correct), $F(2,12)=63.93$, $p<.0001$; $F(2,12)=129.05$, $p<.0001$; b) responses to negative instructions were slower on deadline block 3 and globally less accurate than those to positive instructions (1130 vs. 1087 msec; .77 vs. .79 correct), $F(1,6)=14.35$, $p<.009$; $F(1,6)=6.10$, $p<.048$; c) all 11 adjacent month pairs were not processed equally rapidly and accurately, $F(10,60)=12.58$, $p<.0001$; $F(10,60)=9.54$, $p<.0001$; d) although this effect of pairs was, on latency, present in all three deadline blocks, it was much more pronounced in deadline blocks 2 and 3 than in deadline block 1, $F(20,120)=8.81$, $p<.0001$; On accuracy, it was present only in the first two deadline blocks and was much more pronounced in the first than in the second block, $F(20,120)=5.72$, $p<.0001$; e) the Attribute X Sign X Pair interaction was significant on both measures ($F(10,60)=8.10$, $p<.0001$; $F(10,60)=3.14$, $p<.003$) indicating the presence of a larger congruity effect in condition 2 ("less late/later") than in condition 1 ("less early/earlier") on latency and of a larger congruity effect in condition 1 than in condition 2 on accuracy; and finally f) the Deadline X Sign X Attribute X Pair interaction was significant on both measures ($F(20,120)=1.94$, $p<.015$; $F(20,120)=2.27$, $p<.003$). On latency, it indicated the presence of a congruity effect in both conditions in all deadline blocks except for deadline block 1 in condition 1, $Fs(10,60)>2.53$, $p<.013$. This effect was overall more pronounced in deadline blocks 2 and 3 than in deadline block 1. On accuracy, it indicated the presence of a larger congruity effect in deadline block 1 than in deadline blocks 2 and 3 in condition 1, and the presence of this effect only in deadline block 2 in condition 2.

Several conclusions may be drawn from these analyses. First, our manipulation of the emphasis on speed vs. accuracy of responses was highly effective. Response times and percentages of correct responses increased as the emphasis put on accuracy also increased. Furthermore, the percentages of correct responses obtained in each deadline block were very similar to those originally expected in the choice of our deadlines.

Second, our results also indicate that as more emphasis was put on accuracy than on speed of response, response times became increasingly sensitive to variations in the processing difficulty of the stimulus pairs. Inversely, percentages of correct responses became increasingly less sensitive to such variations. The magnitude of the effect of stimulus pairs on latency increased in both experiments from deadline blocks 1 to 3. Inversely, this effect on accuracy decreased from blocks 1 to 3.

Third, an overall response time congruity effect was detected in three out of four conditions. It was not detected in condition 2 of Experiment 3 ("less early/less late"). A congruity effect was also detected on accuracy in some conditions (e.g., deadline block 2 of condition 2 of both experiments). This particular result is inconsistent with Petrusic and Baranski's claim that accuracy is insensitive to variations in the difficulty of the decision process and thus cannot display a congruity effect. Our results indicate that this measure can, in contexts of moderate speed emphasis, reflect such variations.

The form of the congruity effects obtained in Experiment 4 were on two points similar to those obtained in the first two experiments presented in chapter II. First, the overall form of this effect in each deadline block of each condition tended to be that of an inversed W on latency, and of a W on accuracy. This result again is consistent with the hypothesis of privileged access to adjacency information at certain points in the month series (at the beginning, middle and end) and consequently with that of a multidimensional perception of the months of the year in the symbolic paired-comparison task. Second, the form of the response time congruity effect differed, as in the first two experiments, for positive and negative instructions. For positive instructions, response latencies were shorter if the polarity of the attribute was congruent with the position of the stimulus pair in the month series than if it was not. As for negative instructions, the form of this effect tended to be the exact reversal of that obtained with their positive equivalent in deadline block 2 and to be funnel-shaped in deadline block 3. Although a definite conclusion cannot be reached on the basis of these results concerning the way in which subjects processed negative instructions, one possible strategy nonetheless can be ruled out. This strategy consists in performing the comparison as if the instruction was positive, by attending only to its attribute and then switch responses.

Finally, and most importantly, the magnitude of the congruity effect obtained in conditions 1 ("less early/earlier") and 2 ("less late/later") of Experiment 4 was, as in Petrusic and Baranski's 1989 study, affected by the relative demands made on speed vs. accuracy of responses. The congruity effect tended to be more pronounced on latency when more emphasis was put on accuracy than on speed of response and to be more pronounced on accuracy in a context of moderate speed emphasis. These results lend support to a decisional locus of the congruity effect and thus are consistent with decisional models such as Holyoak's reference point model. Inversely, they are inconsistent with models assuming a pre-decisional locus such as the expectancy model and those assuming a post-decisional locus of this effect such as Banks' semantic coding model[8].

The magnitude of the congruity effect on response times for correct vs. incorrect responses was also examined in the first two deadline blocks. It was not examined in the third deadline block since in this context subjects made very few errors. A statistical comparison of the magnitude of the congruity effect for correct and incorrect responses was not possible in this context[9]. Figures 3.8 to 3.11 illustrate this effect in conditions 1 ("earlier/later", "less early/earlier") and 2 ("less early/less late", "less late/later") of Experiments 3 and 4, respectively.

An analysis of variance performed on the mean response time of correct responses indicated the presence of an overall congruity effect in condition 1 of Experiment 3 ($F(10,60)=2.47$, $p<.015$) and in both conditions of Experiment 4 ($F(10,60)=2.00$, $p<.049$; $F(10,60)=4.56$, $p<.0001$) The magnitude of this effect differed significantly when considering each deadline block separately only in Experiment 4 ($F(10,60)=2.02$, $p<.046$). This effect was highly significant in deadline block 2 for both conditions ($F(10,60)=3.43$, $p<.001$; $F(10,60)=5.60$, $p<.0001$), and was marginally significant in deadline block 1 only in condition 2 ($F(10,60)=1.90$, $p<.063$). The same analyses performed on the mean response time of incorrect responses indicated the presence of an overall congruity effect only in condition 2 of Experiment 4 ($F(10,60)=1.96$, $p<.054$). This effect was not detected in any other condition.

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[8] The congruity effects observed in Experiment 3 were overall much smaller than those observed in Experiment 4 and hence their magnitude was not affected by the relative demands for speed vs. accuracy of response.

[9] Note that some subjects did not make any errors for a few pairs in deadline block 2. The value of the response time on these trials was estimated by interpolation, by considering the pattern of response times for the other stimulus pairs. If this had not been done, an analysis of variance could not have been performed in this context since the SPSSX procedure MANOVA eliminates all cases for which missing values are found.

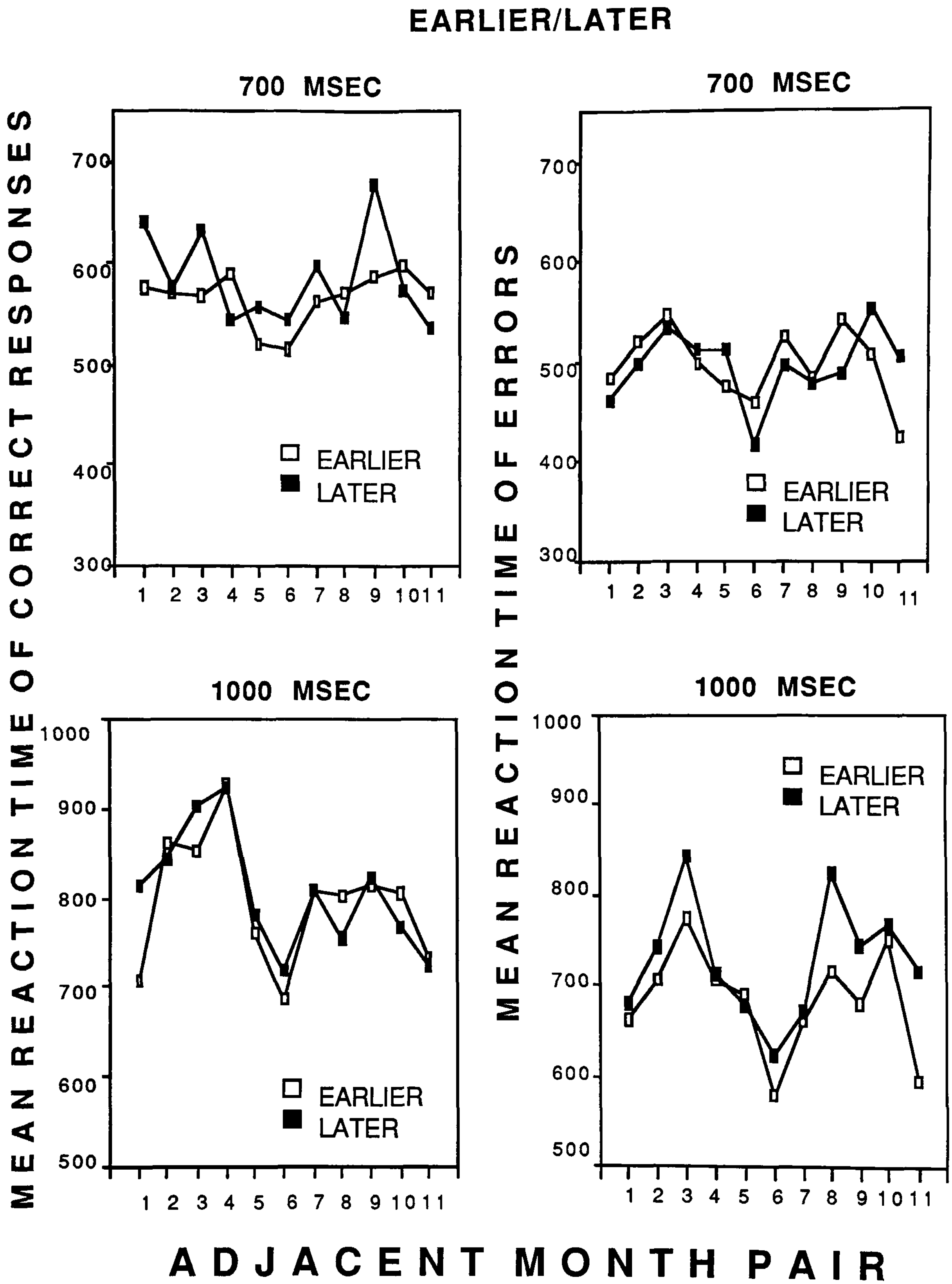

Figure 3.8 Semantic congruity effects obtained on mean latency of correct and incorrect responses in condition 1 of Experiment 3 (earlier/later)

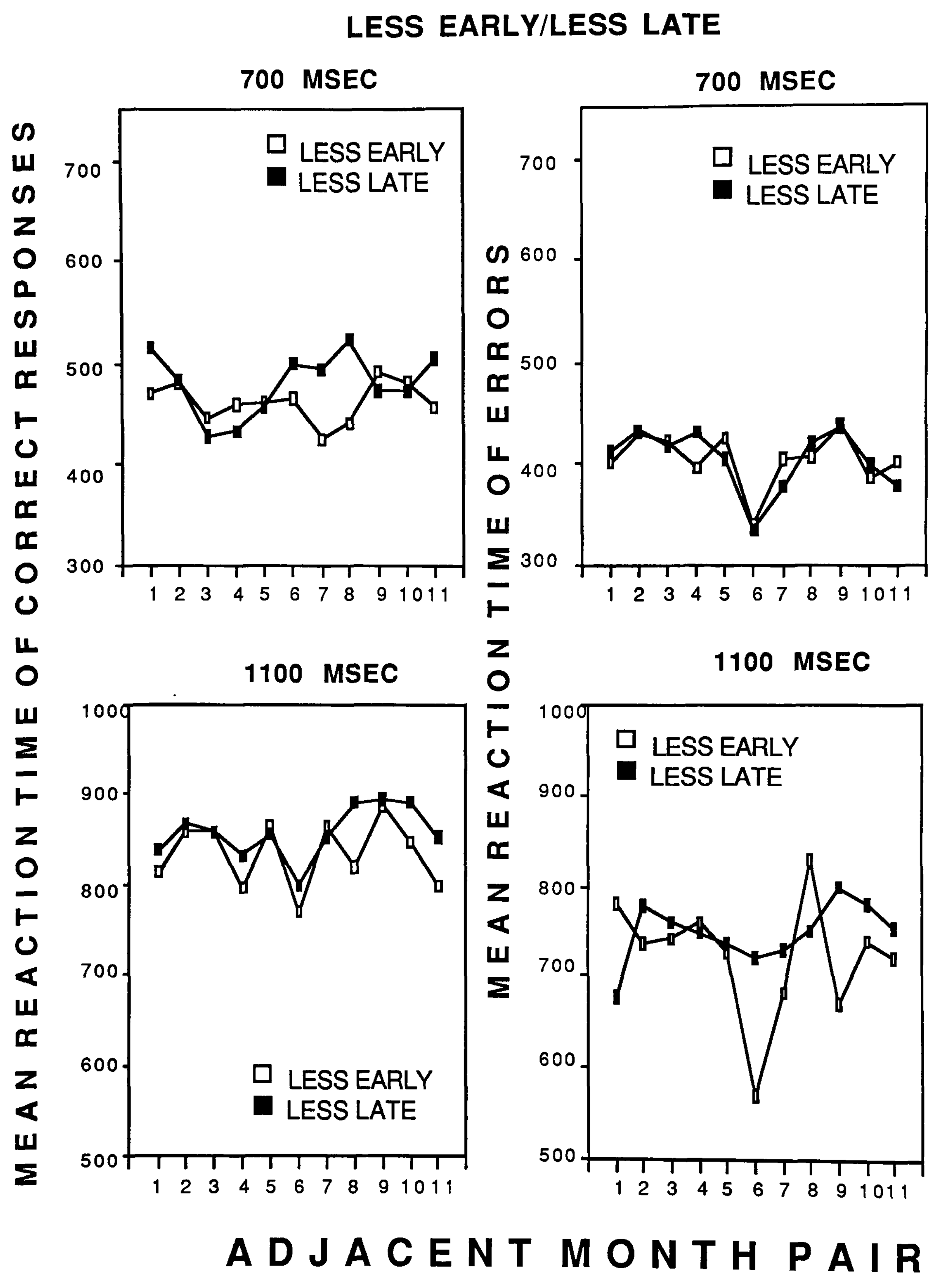

Figure 3.9 Semantic congruity effects obtained on mean latency of correct and incorrect responses in condition 2 of Experiment 3 (less early/less late)

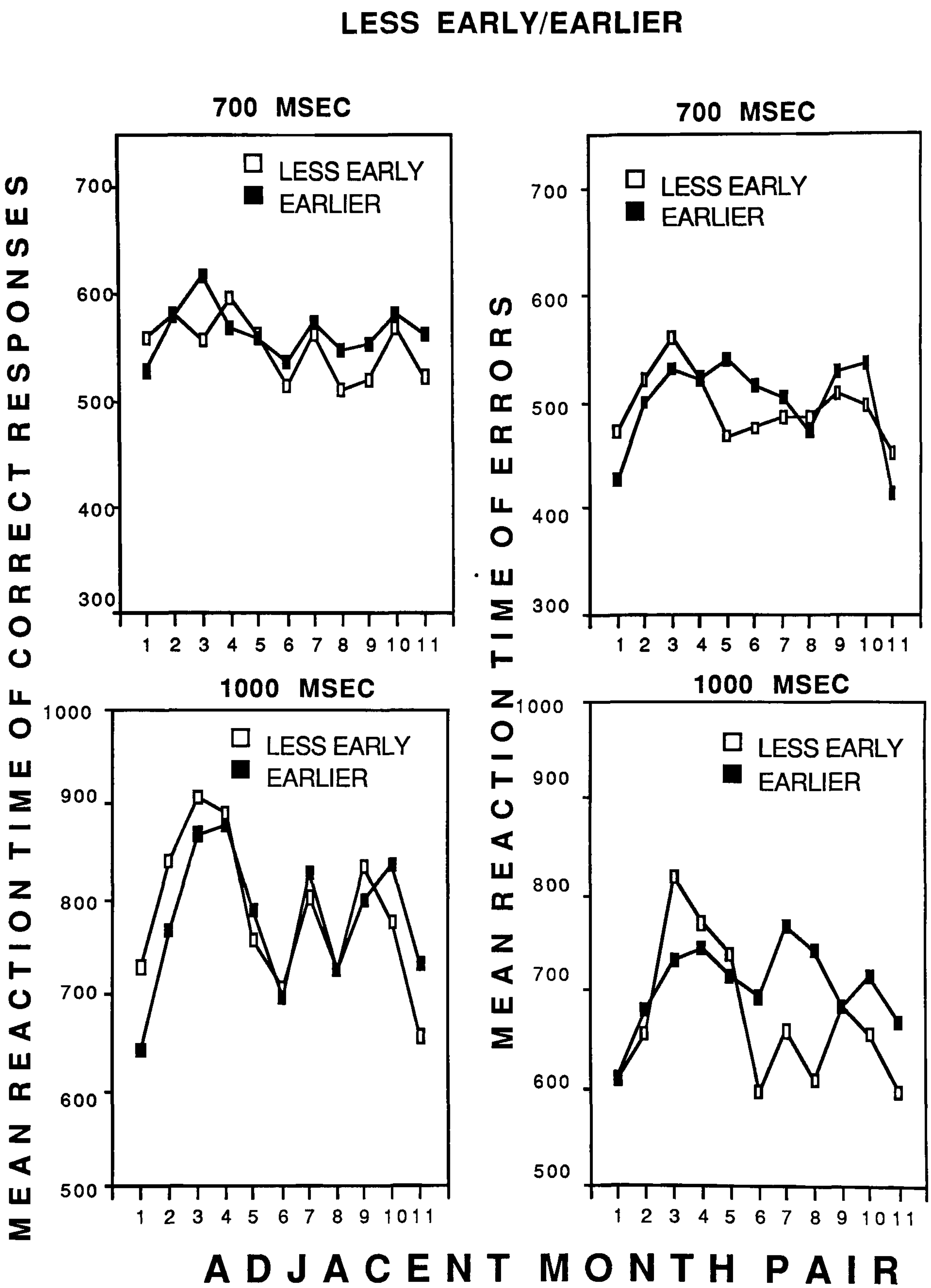

Figure 3.10 Semantic congruity effects obtained on mean latency of correct and incorrect responses in condition 1 of Experiment 4 (less early/earlier)

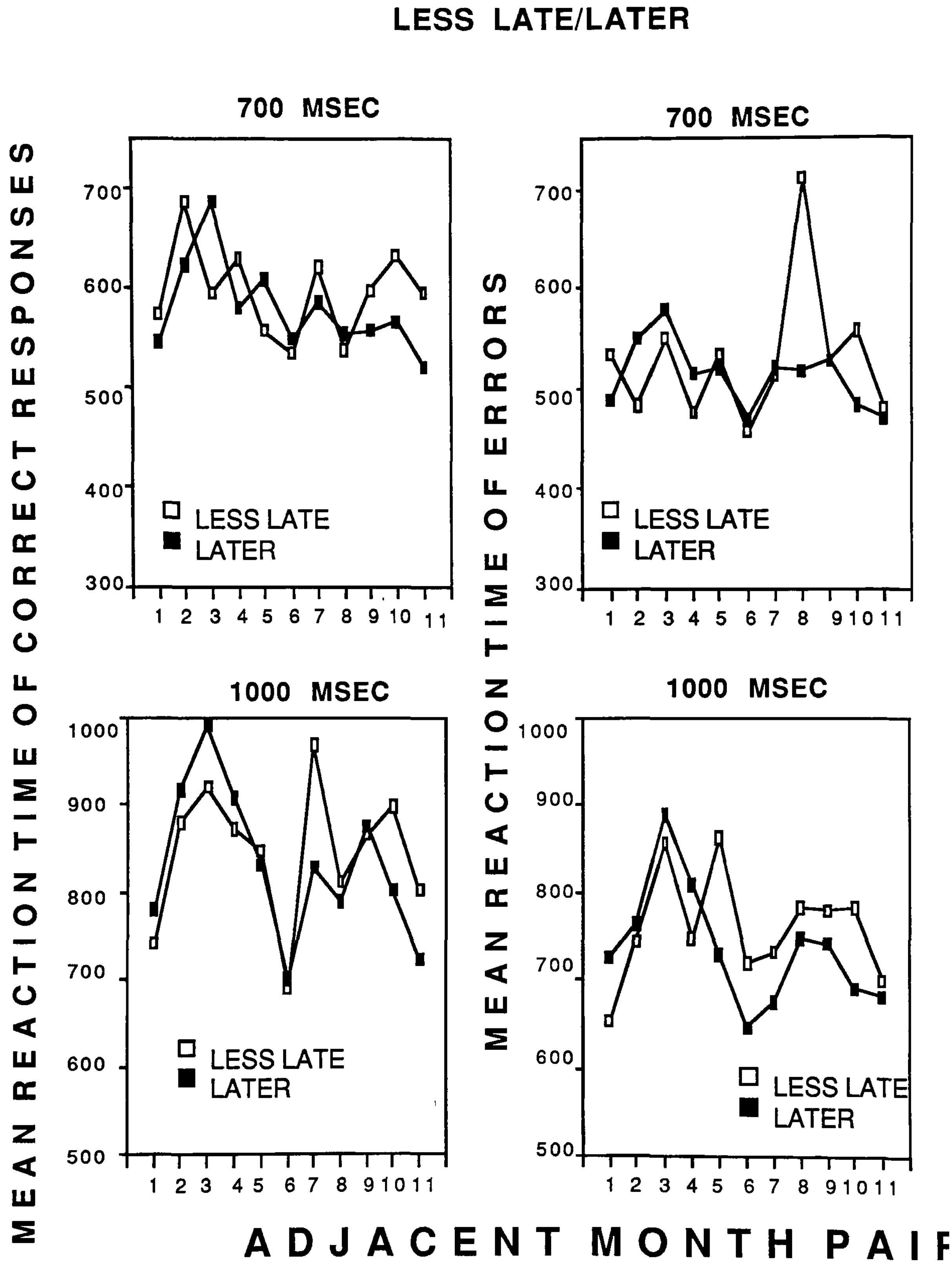

Figure 3.11 Semantic congruity effects obtained on mean latency of correct and incorrect responses in Condition 2 of Experiment 4 (less late/later)

Furthermore, the magnitude of this effect did not, in any condition, differ significantly when considering each deadline block separately ($\underline{F}(10,60)=0.86$, $\underline{p}<.57$; $\underline{F}(10,60)=0.55$, $\underline{p}<.85$).

In order to compare the magnitude of the congruity effect on the latency of correct vs. incorrect responses, an estimate of the size of this effect was computed in each deadline block of each condition for both the latency of correct and incorrect responses. The statistic used in order to do so is the partial eta-squared.

The results of this computation indicated that the magnitude of the overall congruity effect was larger on response times of correct than of incorrect responses in both conditions of Experiment 4 (partial $eta^2=.25$ for correct vs. .155 for incorrect responses in condition 1; and .432 for correct vs. .246 for incorrect responses in condition 2) and in condition 1 of Experiment 3 (partial $eta^2=.29$ for correct vs. .129 for incorrect responses). The proportion of variance accounted for by this effect was larger for correct than for incorrect responses. This difference in magnitude of the congruity effect for correct and incorrect responses increased in Experiment 4 from deadline blocks 1 (partial $eta^2=.084$ for correct vs. .068 for incorrect responses in condition 1; and .24 for correct vs. .206 for incorrect in condition 2) to 2 (partial $eta^2=.364$ for correct vs. .213 for incorrect responses in condition 1; and .483 for correct vs. .203 for incorrect responses in condition 2).

Finally, correct responses were overall slower than incorrect responses in all conditions (688 vs. 602 msec in condition 1 of Experiment 3; 658 vs. 570 msec in condition 2 of Experiment 3; 669 vs. 593 msec in condition 1 of Experiment 4; 714 vs. 635 msec in condition 2 of Experiment 4), and this difference in response times between correct and incorrect responses increased in Experiment 4 from deadline blocks 1 (559 vs. 498 msec in condition 1; 589 vs. 521 msec in condition 2) to blocks 2 (777 vs. 689 msec in condition 1; 838 vs. 748 msec in condition 2).

The above results are not consistent with Holyoak's reference point model which predicted equal response times and consequently congruity effects of equal magnitude for correct and incorrect responses. They also do not replicate the findings of Petrusic and Baranski (1989), who noted the presence of larger congruity effects on incorrect than on correct responses. Furthermore, the conclusions that can be drawn from these results are inconsistent with those that pertain to the magnitude of the congruity effect in each deadline block. The presence of larger response time congruity effects in deadline block 3 than in deadline blocks 1 and 2 of Experiment 4 are in accord with Holyoak's model. Inversely, the presence of larger congruity effects on correct than on incorrect responses are in accord with Banks' semantic coding model.

Note, however, that although no statistical test was performed in deadline block 3, incorrect responses were slightly slower than correct responses in this block in conditions 1 (1157 vs. 1110 msec) and 2 (1132 vs. 1108 msec) of Experiment 4. This result suggests that subjects may have adopted different decisional strategies according to the requirements for fast vs. accurate decisions. When more weight was given to speed of responses, error times seemed to reflect the presence of fast-guess strategies. However, when more weight was given to accuracy of responses, error times, were, in several cases, very long and seemed to reflect the use of "accumulative" strategies as those depicted in the accumulator model. Since subjects could adopt different decisional strategies in each deadline block, the predictions concerning the magnitude of the congruity effect on correct vs. incorrect responses may differ in each deadline block. Hence, an evaluation of Banks' or Holyoak's models is not as straightforward as originally thought. One of these two models cannot, on the basis of these data, be rejected unequivocally.

A SEPARATION OF MNEMONIC AND PERCEPTUAL PROCESSES FROM DECISIONAL PROCESSES: A STUDY OF THE SAT FUNCTION

In order to obtain a measure of the processing difficulty of the sign and of the attribute of the comparative instruction, free of bias resulting from possible variations in the response criteria adopted, a SAT function was drawn for each form of this instruction in each condition of Experiments 3 and 4. The data of Experiments 1 and 2 were also reanalysed in this way. The results of this reanalysis will be presented first, followed by those of Experiments 3 and 4.

Response times for each form of the comparative instruction, averaged over subjects, sessions and month pairs[10], were first ordered from the shortest to the longest in each condition of Experiment 1 and 2, and in each deadline block of each condition of Experiment 3 and 4. This distribution was then cut into eight categories[11], with an equal number of responses per category. The mean response time and mean percentages of correct responses in each of these categories were then plotted one against the other. Figures 3.12, 3.13 and 3.14 illustrate these functions generated in Experiments 1 and 2, 3 and, 4, respectively.

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[10] In Experiments 1 and 2, all possible non-identical month pairs (132 pairs) were presented. However, only the adjacent month pairs were considered when computing the SAT functions. This was done in order to reduce as much as possible the importance of this source of variation (month pairs) and make these functions more comparable to those of Experiments 3 and 4.

[11] Note that the number of responses averaged per category was 385 in Experiments 1 and 2 and 220 in Experiments 3 and 4. The decision to partition the response time distribution into eight was only partly arbitrary. Ideally, the SAT function seeked should be formed of the largest number of data points as possible. However, since the dependent variable considered was latency, and that this variable requires a large number of observations (to serve as replications) to provide a stable measure of central tendency, each point of this function had to represent a mean of a large number of observations. Furthermore, since in our experiments a large number of stimuli was used and that a separate SAT function could not be drawn for each stimulus, each point of this function had to represent an even larger number of observations.

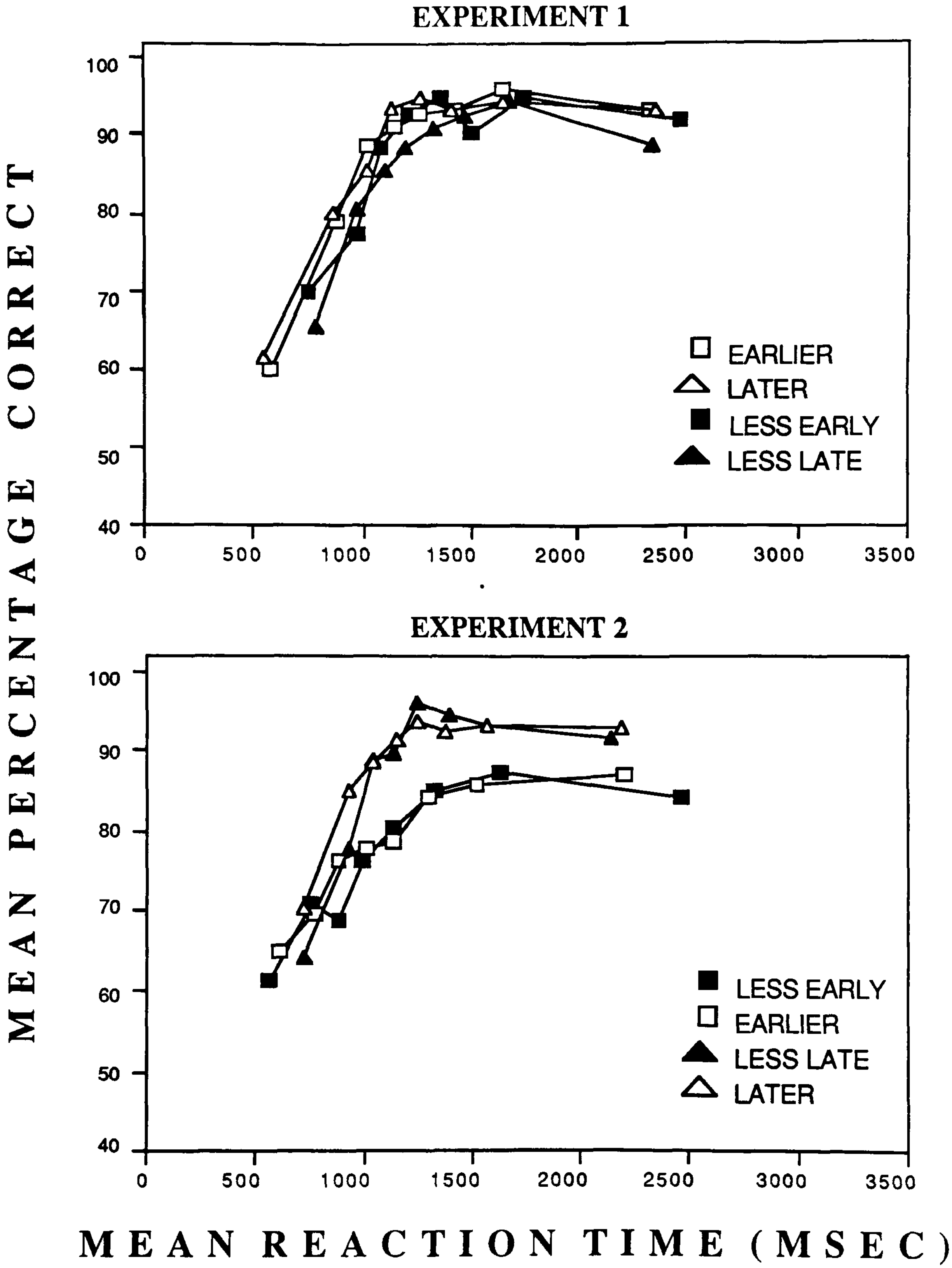

Figure 3.12 Speed/accuracy tradeoff functions generated in Experiments 1 and 2

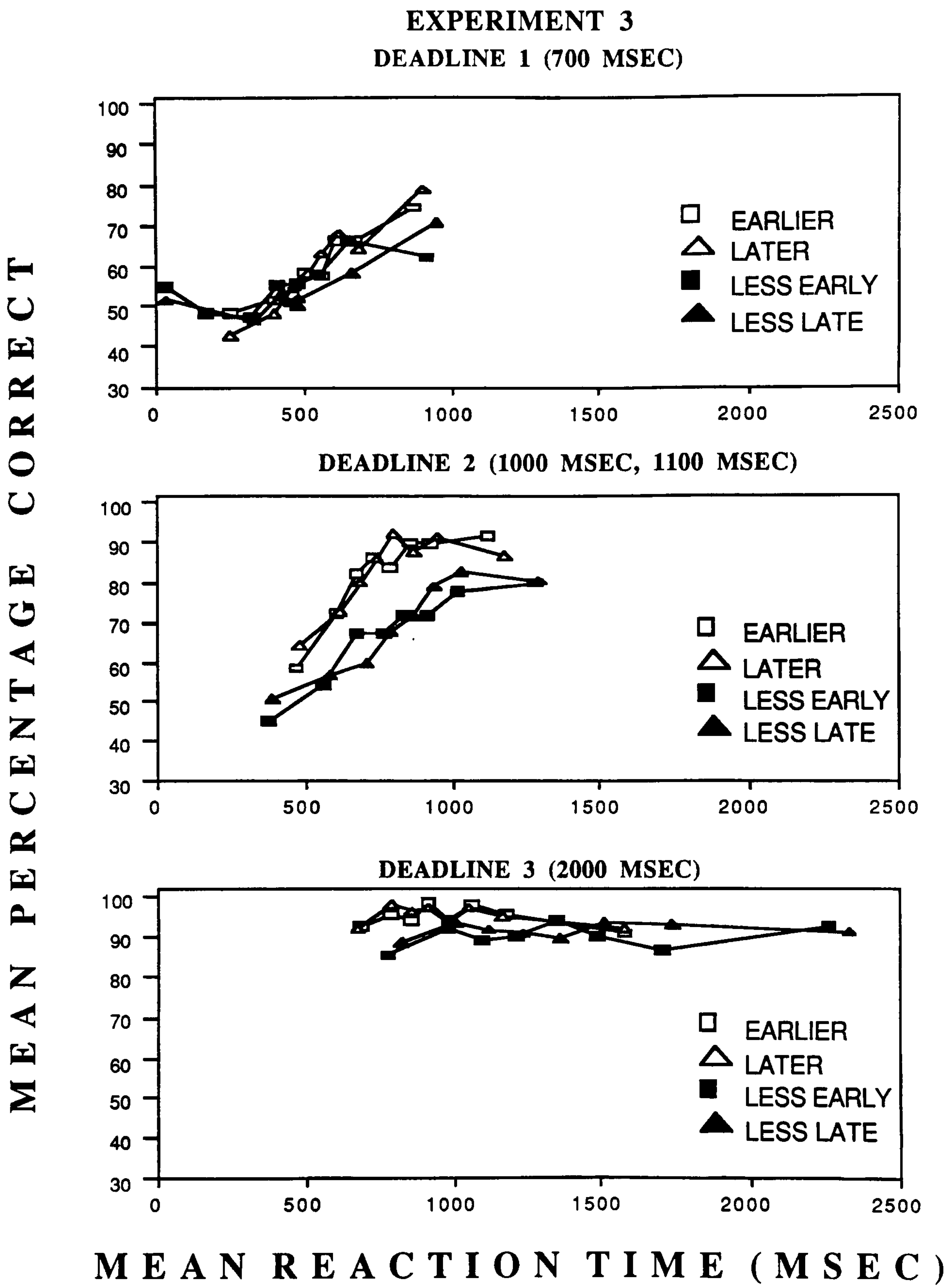

Figure 3.13 Speed/accuracy tradeoff functions generated in each deadline block of Experiment 3

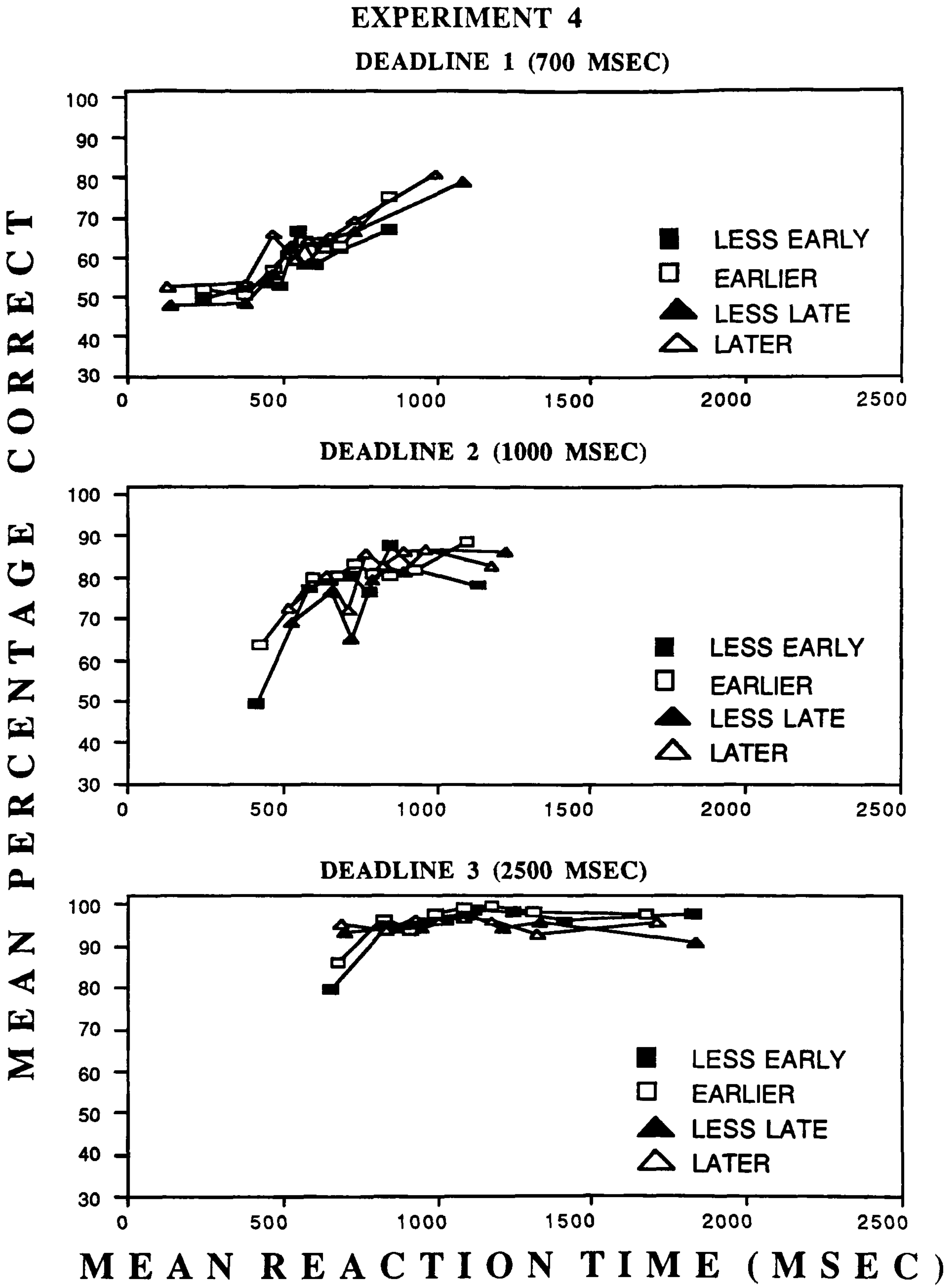

Figure 3.14 Speed/accuracy tradeoff functions generated in each deadline block of Experiment 4

A sign effect was clearly more apparent when the sign of the instruction was manipulated between- (in Experiments 1 and 3) rather than within-subjects (in Experiments 2 and 4). This effect manifested itself in Experiment 1 by altering the intercept of the SAT function on the x-axis. Subjects who received negative instructions could not start responding before at least 744 msec. Inversely, those receiving positive instructions could respond in as little as 539 msec. This result suggests that the locus of the sign effect was in the initial encoding stage.

In order to determine if the difference noted in the value of the intercept for positive and negative instructions was significant, the SAT functions were fitted by the following exponential equation, suggested by Wickelgren (1977): $\text{accuracy}=I(1-e^{-\tau(RT-\delta)})$[12]. This equation has three parameters: 1) an intercept on the x-axis (δ), 2) a slope (τ), and 3) an asymptote on the y-axis (I). The value of the intercept was estimated to be 282 $\pm$ 136 msec for "earlier" (146 418 msec), 209 $\pm$ 211 msec for "later" (-002 - 420 msec), 385 $\pm$ 370 msec for "less early" (15 - 755 msec) and, 509 $\pm$ 156 msec for "less late" (353 - 665 msec). The difference in the value of this parameter was interpreted as being significant since the confidence interval of this parameter for positive vs. negative instructions differed greatly[13].

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[12] First, note that not all curves were fitted. Only those having a form similar to this exponential function and which depicted an effect of the sign or of the attribute of the instruction, were fitted. Second, the fit was not performed on the raw data. It was performed on the grouped data, that is, the eight data points forming each SAT function. The fit could not be performed on the raw data because one of the variables, response accuracy, was dichotomic. The fit, as performed by averaging over subjects, sessions, and pairs, was consistent with the way in which the functions were drawn. The proportion of variance accounted for by this fit was, for all comparative instructions larger than .87 in Experiment 1, .91 in Experiment 2, .88 in Experiments 3, and .53 in Experiment 4.

[13] Note that a more formal test of the sign and lexical marking effects could have been performed by means of a t-test. This test would have enabled us to determine if the difference noted in the value of the SAT function's parameters for positive vs. negative instructions and instructions containing a marked vs. an unmarked

A sign effect was apparent in Experiment 3 in mainly three different ways: 1) by a larger percentage of extremely fast responses at a level of accuracy of chance (fast-guess responses) in deadline block 1 and hence, an overall much smaller mean response time for negative than for positive instructions in this block; 2) by the presence of extremely larger response times for negative than for positive instructions in deadline block 3; and 3) a smaller slope of the SAT function for negative than for positive instructions in deadline block 2. The value of this parameter, estimated when fitting the SAT function by the exponential equation described above, was 4.71 $\pm$ 2.47 for "earlier" (2.24 - 7.18), 5.59 $\pm$ 5.77 for "later" (-0.18 11.36), 1.91 $\pm$ 1.61 for "less early" (0.30 3.53) and, 1.18 $\pm$ 2.73 for "less late" (-1.55 3.91). The difference in slope for positive vs. negative instructions was interpreted as being significant since the overlap between the confidence interval of this parameter for both instructions was very small.

When the sign of the instruction was manipulated within-subjects (in Experiments 3 and 4) a sign effect was not apparent. The confidence interval of all three parameters of the SAT function for positive vs. negative instructions overlapped greatly. A slightly larger percentage of correct responses, however, was noted for positive than for negative instructions in each deadline block of conditions 1 (.61 vs. .58 in block 1; .80 vs. .76 in block 2; .96 vs. .94 in block 3) and 2 of Experiment 4 (.64 vs. .60 in block 1; .81 vs. .78 in block 2; .95 vs. .94 in block 3).

A lexical marking effect (an effect of the attribute) was clearly apparent only in Experiment 2 in which this variable was manipulated between-subjects. The slope of the SAT function was smaller and its asymptote on the y-axis, lower for instructions containing the adjective "early" than those containing the adjective "late". The value of the slope and asymptote parameters, estimated when fitting the SAT functions by

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adjective was statistically significant. A t-test, however, could not be performed since we were unable to estimate the standard error of the difference in parameter. The regression program used did not enable us to obtain this estimate. Furthermore, we were unable to find the formula required to obtain this value.

Wickelgren's exponential equation, were 2.02 ± .93 (1.09 - 2.95) and .89 ± .05 percentage correct (.84 - .94) for "earlier", 2.18 ± 1.83 (0.35 4.01) and .87 ± .08 percentage correct (.79 .95) for "less early", 5.34 ± 1.63 (3.71 - 6.97) and .93 ± .02 percentage correct (.91 - .95) for "later" and, 4.42 ± 3.04 (1.38 7.46) and .95 ± .06 percentage correct (.89 - 1.01) for "less late". An examination of the confidence interval of both parameters for instructions containing a marked vs. an unmarked adjective suggested that the difference noted in the value of these two parameters for both types of instructions was significant.

The above results suggest several things. First, they suggest that the sign of the instruction was a more important source of difficulty of the overall decision process than the attribute of the instruction.

These results also suggest that the sign of the instruction affected the difficulty of the overall decision process much more when it was manipulated between- rather than within-subjects. The presence of a much smaller sign effect when the sign of the instruction was manipulated within-subjects may reflect a gradual decrease in the difference in complexity between positive and negative instructions with extended practice. The pairing of negative with positive instructions may, with practice, render the former much less difficult to process.

There also was some indication that the sign effect manifested itself differently depending on whether the emphasis put on speed vs. accuracy of responses was or not manipulated. This effect manifested itself in more ways when the emphasis put on speed vs. accuracy was manipulated (in Experiment 3) than when it was not (in Experiment 1). Much less diversity was noted in the types of responses given in Experiment 1 than those given in Experiment 3. Subjects could, in the latter experiment, adopt different decisional strategies in each deadline block. Fast-guess responses were, for instance, noted only in Experiment 3 since, in this experiment, subjects were on some blocks of trials required to put much more emphasis on speed than on accuracy of responses. Conversely, subjects of Experiment 1 were not required and did not spontaneously put as much emphasis on the speed of their responses.

Furthermore, the change in slope noted for positive vs. negative instructions in deadline block 2 of Experiment 3 suggests that subjects in this context adopted a different strategy to process negative instructions than those of Experiment 1. Subjects of Experiment 1 appeared to recode negative instructions into their positive equivalent during the encoding stage. Accordingly, the sign of the instruction altered only the intercept of the SAT function in this experiment. Inversely, subjects of Experiment 3 may, in deadline block 2, have recoded the stimuli into a negative format or the negative instruction into its positive equivalent during the comparison stage. The form of the congruity effect obtained with negative instructions in this context suggests, that the second of these two strategies was used. The form of this effect, in this context, was the reversal of that obtained with positive instructions.

Finally, correct responses were, as pointed out earlier, slower than incorrect responses in the first two deadline blocks of Experiments 3 and 4. These results lend support to Yellot's Fast guess model, and are inconsistent with the simple random walk and accumulator models. We must however be cautious in attempting to reject these two models on the basis of the above results because 1) Incorrect responses were slower than correct responses in deadline block 3 of conditions 1 and 2 of Experiment 4, and 2) the predictions derived from these models concerning the form of the micro SAT function may be, as pointed out by Pachella (1974), too simplistic. As outlined, all three models make distinct predictions. However, a "reasonable complication" of these models may confound their predictions. If, for instance, as argued by Pachella, the random walk or accumulator models posit that subjects may vary their criterion for responding within a particular speed-emphasis condition, the predicted micro SAT function will show slower correct than incorrect responses.

General discussion

One first objective of the experiments presented in this chapter was to extend the evaluation of Banks' semantic coding model and Holyoak's reference point model by studying the effect of the relative demands for speed vs. accuracy of responses on the magnitude of the semantic congruity effect. Petrusic and Baranski (1989) classified both models according to the locus of this effect in each model. Banks' model was classified as "post-decisional" and Holyoak's model as "decisional". The speed/accuracy emphasis manipulation was expected to affect the magnitude of the congruity effect only in the context of "decisional" models. Our results indicated that the magnitude of this effect on latency, in conditions 1 ("less early/earlier") and 2 ("less late/later") of Experiment 4, was larger when more emphasis was put on accuracy than on speed of response. These results suggest that the congruity effect has a "decisional" locus and, consequently, enable a refutation of Banks' semantic coding model, but this only if Petrusic and Baranski's classification is accepted. This classification may be questioned. Banks' model was classified as "post-decisional" because the code translation operation accounting for the congruity effect, occurs after the creation of discriminable stimulus codes. The code translation operation occurs during the comparison stage in which the stimulus codes are compared to the instruction code. It seems to be at this stage that a decision is made and thus one must wonder what Petrusic and Baranski meant by a "decisional" or a "post-decisional" locus of this effect. Nonetheless, even if these results may not enable a refutation of Bank's model, they clearly support a "decisional" locus of the congruity effect.

Our results also indicated that response accuracy can, in context of moderate speed emphasis, reflect variations in the difficulty of the overall decision process and thus display a congruity effect. Finally, our results indicated that correct responses were slower than incorrect responses in deadline blocks 1 and 2 and, consequently, that the magnitude of the congruity effect was larger on correct than on incorrect responses in these blocks. Although Banks' semantic coding model predicted larger congruity effects on correct than on incorrect responses, these results do not necessarily support this model. The prediction derived from Banks' model does not take into account the possibility that subjects may use different decisional strategies depending on the requirements for fast vs. accurate decisions. The same relationship is predicted between correct and incorrect responses independently of the emphasis put on speed vs. accuracy of responses. Our results suggest that subjects did in fact adopt different decisional strategies depending on the requirements for fast vs. accurate decisions. The errors noted in deadline blocks 1 and 2 seemed to result mainly from the use of fast-guess strategies. Conversely, the errors noted in deadline block 3, in which much more emphasis was put on accuracy than on speed of responses, were in two out four conditions slower than the correct responses and seemed to reflect the use of "accumulative" strategies such as those depicted in Vicker's accumulator model.

A second objective of the experiments presented in this chapter was to separate mnemonic processes linked to the interpretation of the comparative instruction from decisional processes linked to the choice of a response criterion. We seeked a measure of the processing difficulty of different forms of the comparative instruction free of bias resulting from variations in the response criteria adopted. However, because of the way in which the SAT function was drawn (by partitioning the obtained response time distributions), our estimates of the processing difficulty of the different forms of the comparative instruction may not be completely free of this bias. This function could not be drawn in another way because of the experimental design initially chosen. First, the emphasis put on speed vs. accuracy of responses was not manipulated in Experiments 1 and 2. Second, although it was manipulated in Experiments 3 and 4, only three deadline blocks were used. A SAT function constituted of only three data points would not have enabled an examination of this function's three parameters and hence a formulation of explicit predictions concerning the effect of different variables on the overall form of this function. One other problem stems from the fact that this function was generated by pooling response times of different sources (subjects, sessions and pairs). This problem, however, could not be avoided since we used a large number of stimuli and did not have enough replications per stimulus or enough observations per subject or per sessions to draw separate SAT functions.

Several authors also have criticized the method of partitioning response times as a means of generating the SAT function and thus the use of micro SAT functions (Wood and Jennings, 1976; Wickelgren, 1977; Grice and Spiker, 1979; Vickers, Burt, Smith and Brown, 1985). Wood and Jennings (1976), in particular, have shown that the micro SAT function (or the conditional accuracy function, CAF, as they termed it) is dependent upon much more stringent assumptions than the macro SAT function (or the SATF as they termed it) and that these assumptions are in practice not respected. The assumptions underlying the use of macro SAT functions are only that: 1) subjects' criteria must vary systematically across the different speed-emphasis conditions; and that 2) mean response time and accuracy are reasonable summary statistics for the bivariate SAT function. Inversely, the assumptions underlying the use of the micro SAT function are that: 1) this function is invariant across changes in response criteria or alternatively that, 2) a given subject's response criterion is constant in the data from which this function is computed. If neither of these conditions is met, then computing accuracy conditional upon obtained RT would mix together trials which have similar RTs but which arise from high-accuracy and low-accuracy criteria. Although, Schouten and Bekker (1967) claimed the invariance of the micro SAT function across different speed-emphasis conditions, Wood and Jennings presented data showing criterion variability and refuting this invariance assumption. These authors presented empirical and computer-simulated data showing that the effects of criterion variability on the micro

SAT functions were both large and variable. Conversely, the macro SAT functions were relatively unaffected by the same changes in criterion variability.

Despite the possibility that our measure of the processing difficulty of the comparative instruction was not entirely free of bias resulting from variations in the response criteria adopted, our results nonetheless suggest that the sign of the instruction affected the difficulty of the overall decision process when manipulated between-subjects. The sign effect also manifested itself differently depending on whether the requirements for fast vs. accurate decisions were or were not manipulated. In Experiment 1, in which these requirements were not manipulated, the sign effect was apparent only at the level of the intercept on the x-axis of the SAT function. This value was larger for negative than for positive instructions. This result suggests that the sign effect manifested itself at the encoding stage and thus is consistent with the hypothesis that negative instructions are recoded into their positive equivalent during this encoding stage. Finally, the sign effect manifested itself in Experiment 3 in three different ways: 1) by a larger proportion of fast-guess responses for negative than for positive instructions in deadline block 1; 2) a larger proportion of extremely slow response times for negative than for positive instructions in deadline block 3; 3) by a smaller slope of the SAT function for negative than for positive instructions in deadline block 2. This last result suggests that the sign effect was, in this context, localized in the comparison stage. The form of the congruity effect obtained with negative instructions suggests however that they were, as in Experiment 1, recoded into their positive equivalent. This recoding operation may have been performed in the comparison stage instead of the encoding stage.

CHAPTER IV

THE MENTAL REPRESENTATION OF THE MONTHS OF THE YEAR IN A DISSIMILARITY JUDGMENT TASK

The outcomes of Experiments 1 and 2 provided us with an empirical basis for inferring the representational properties of the months of the year in the context of the symbolic paired-comparison task. We were interested in determining if characteristics of the stimuli, other than the symbolic distance between both members of the stimulus pair and the position of the pair in the month series, could also affect the overall comparison process and, consequently, the form of the symbolic distance and semantic congruity effects. Our results indicated that aside from the symbolic distance, the following stimulus characteristics appeared to affect the overall comparison process: 1) the length of month names which could serve as a cue for lateness of the months in the year, 2) the presence or absence of an end term in the stimulus pair (January or December) and, 3) the part of the year in which the months fell (first vs. second half). Comparisons were performed much slower when 1) both members of the stimulus pair had names of similar rather than of different length; 2) both members of the month pair fell in the same rather than in different parts of the year and when; 3) the stimulus pair did not contain an end term.

We now report an experiment designed to test the hypothesis according to which the mental representation of months of the year and, consequently, the extent to which inherent characteristics of the months of the year will affect the overall comparison process, is not invariant but depends on the requirements of the task performed.

Sergent and Takane (1987) evaluated a similar hypothesis in a study that dealt with the perception of various multidimensional stimulus sets in the context of speeded same-different and untimed dissimilarity judgment tasks. The present experiment was intended to test the generalizability of Sergent and Takane's findings in the semantic domain of the months of the year. Subjects, in the present experiment, were required to perform untimed dissimilarity judgments. For each presented month pair, subjects had to decide the extent to which both months were similar by placing a mark on a linear continuum ranging from very similar to very different. Multidimensional scaling analyses were then performed. The resulting similarity structure was compared to that presented in chapter II, obtained in the context of the symbolic paired-comparison task. We now turn to a more detailed discussion of Sergent and Takane's study.

Sergent and Takane's (1987) study dealt with the perception of various multidimensional stimulus sets such as circles varying in size and radius inclination, Munsell colours varying in chroma and value, parallelograms varying in size and tilt and, rectangles varying in height and width. Their study was intended to uncover, by means of multidimensional scaling (MDS), the relevant stimulus dimensions and identify the rules governing their combination in the perception of these stimuli. One hypothesis tested was that

> "among the variety of attributes that compose a stimulus, only a portion of them are psychologically relevant and ... that this dimensional relevance is not invariant. It cannot be specified a priori" (Sergent and Takane,

1987; p.314).

Sergent and Takane claimed that the perception of multidimensional stimuli is determined by an interaction between the stimuli and the processor. Thus, when studying the processes underlying the perception of multidimensional stimuli, two things must be taken into account: 1) the particular characteristics of the stimuli and 2) the particular performance conditions imposed on the subjects such as the mode of presentation of the stimuli (unlimited vs. limited viewing conditions) and the time allotted to produce a response.

The stimuli in a large number of studies on visual perception, are presented for very brief periods by means of a tachistoscope. This mode of presentation has been shown to affect the stimulus contents which can be extracted and processed. Stanovich (1979) and Santee and Egeth (1982) suggested that stimulus processing in such conditions relies only on partial information. Furthermore, Lockhead (1972; 1979) suggested that a stimulus is first perceived and processed holistically. Its attributes are not initially separable or distinct but are perceived as a unitary entity. Stimulus dimensions which are clearly separable under unlimited viewing conditions may not be as distinct when the stimuli are presented very briefly. Hence, the mode of presentation may determine, according to Sergent and Takane, the characteristics of the stimuli that are the most salient and available for processing and influence the nature of the dimensions perceived.

The time given to subjects to make a response also may influence considerably the perception of multidimensional stimuli. Sergent (1984) suggested that when subjects are required to respond rapidly, the most salient stimulus features will not only be the easiest to discriminate but also those which will be processed first. Differences in processing stimulus dimensions thus may emerge, depending on whether speed requirements are involved or not. Takane and Sergent (1983), for instance, found that the similarity structure of face stimuli derived from untimed dissimilarity judgment and same-different reaction time tasks differed considerably. The eyes and eyebrows were the most salient stimulus dimensions in the untimed task. Inversely, the hair style, jaw and chin were given much more weight than the eyes and eyebrows in the reaction-time task. Smith and Baron (1981) also noted differences in stimulus processing for timed and untimed tasks. They noted that the amount of interference created by irrelevant dimensions in the classification of integral perceptual was much larger in timed than in untimed tasks.

The above results thus indicate that data limitations inherent in tachistoscopic stimulus presentations and resource limitations inherent in response time tasks (Norman and Bobrow, 1975) directly influence the characteristics of the stimuli that can be extracted and processed. Performance is degraded in data-limited tasks because the stimulus information to be processed is less than optimal. In contrast, performance is degraded in resource-limited tasks because not enough processing capacity has been allocated to the task (Stanovich, 1979).

Sergent and Takane (1987) compared the similarity structure of various stimulus sets obtained with the following two similarity measures: 1) RT data obtained in a same-different judgment task and 2) dissimilarity judgments obtained in an untimed dissimilarity judgment task. The similarity structure of these stimulus sets was found to differ considerably in both contexts and this even though the same mode of stimulus presentation (unlimited viewing conditions) prevailed in both tasks. Sergent and Takane attributed this difference in similarity structure to the nature (two-choice same-different decision vs. dissimilarity rating) and the mode (speeded vs. untimed) of the responses given. Their results also indicated, in accord with previous studies, a tendency for stimuli which possess attributes usually perceived as separable, to be treated as integral in the speeded task.

In the present experiment, the mental representation (similarity structure) of the months of the year in an untimed dissimilarity judgment task was examined and compared to that obtained in the symbolic paired-comparison task of Experiments 1 and 2. The mode of presentation of the stimuli did not, as in Sergent and Takane's study, differ in both tasks. Unlimited viewing conditions prevailed in both contexts. The mental representation of months of the year in the present experiment and consequently the characteristics of these stimuli relied upon in producing a response were expected, on the basis of the results obtained by Smith and Baron (1981), Sergent (1984) and Sergent and Takane (1987), to differ tremendously from that observed in Experiments 1 and 2. The nature of the task (dissimilarity judgments vs. earliness/lateness judgments) and the mode of the responses given (speeded vs. untimed), as in Sergent and Takane's study, in both tasks.

The form of the presented stimuli was also manipulated in this experiment. One group of subjects was presented with month names in their usual form while a second group of subjects was presented with month names in an abbreviated form (i.e., Jan, Feb, ... Nov, Dec). The reason for this manipulation was to determine if the length of month names could in the present task, as in the paired-comparison task, affect the overall decision process. This manipulation enabled us to test the hypothesis according to which this stimulus characteristic was perceptually salient only in the paired-comparison task and was relied upon in this task because it could serve as a cue for lateness of the months in the year.

Method

Subjects

Two groups of undergraduate students (76 students in the first group and 86 students in the second group) enroled in a Psychology introductory course at the University of Ottawa served as volunteer subjects.

Stimuli and material

The stimuli consisted in all possible non-identical pairs of the months of the year, with the first member of the pair always being earlier than the second (66 pairs).

The material consisted in a questionnaire that contained three parts. The first part consisted in instructions on how to perform the judgments. The second part consisted in the presentation of all stimulus pairs in one of five different random orders. Each month pair was centered above a 10.2 centimetres linear segment labelled "very similar" at the left end and "very different" at the right end. Only two pairs were printed per page. Finally, the last part consisted in a set of questions designed to obtain from the respondents an introspective report of the stimulus characteristics they used as a basis for their judgments. In the first condition, the month names were presented in their usual form while, in the second condition they were presented in an abbreviated form (Janv, Fev, Mars, Avril, Mai, Juin, Juil, Aout, Sept, Oct, Nov, Dec). One form of the questionnaire is presented in Appendix E.

Procedure

The nature of the dissimilarity judgement task was first explained. For each presented month pair, subjects were required to perform dissimilarity judgments by placing a mark on a linear continuum ranging from very similar to very different. Subjects were not given any indication concerning the characteristics of the months of the year on which to base their responses. However, they were encouraged, before starting, to think of the characteristics inherent to each month. Furthermore, they were asked not to hesitate to use the entire continuum when performing their judgments and to try to be as precise as possible when making a mark so that this mark reflects accurately the extent to which they considered both months as being similar. A questionnaire was then distributed to each student in the class. No constraint was imposed on the time required to make a response.

Results and discussion

To examine the mental representation of the months of the year in the context of the untimed dissimilarity judgment task, a nonmetric multidimensional scaling (MDS) analysis was performed on the dissimilarity ratings in both conditions[14]. The ratings were scaled by using the weighted individual differences euclidian distance model, as proposed by Carroll and Chang (1970).

Two-dimensional solutions accounted best for the dissimilarity rating data in both conditions[15]. Two characteristics of the months of the year thus appeared to influence, in each condition, the overall decision process. Visual inspection of the stimulus configuration suggested that these characteristics corresponded, in both conditions, and by order of importance, to 1) the temperature associated with each month (warm vs. cold weather) and 2) the part of the year in which the months fell (first vs. second half). Figures 4.1 and 4.2 illustrate the stimulus configuration obtained in both conditions. This configuration, in both cases, reproduces very nicely the cycle of the months of the year. The order of the months of the year is in both configurations

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[14] The program used for this analysis was, as in Chapter 2, ALSCAL implemented in SPSSX, which uses the alternating least-square approach proposed by Takane, Young and deLeeuw (1977) and later improved by Young, Takane, and Lewyckyj (1978). The data were treated 1) as dissimilarities, 2) as being ordinal, using Kruskal's (1964) least-squares transformation, and 3) as being continuous.

[15] These solutions had stress values (Kruskal's form 1) and squared correlations in distances (RSQ), averaged over matrices, of 0.253 and 0.552, and of 0.244 and 0.575 in conditions 1 and 2, respectively.

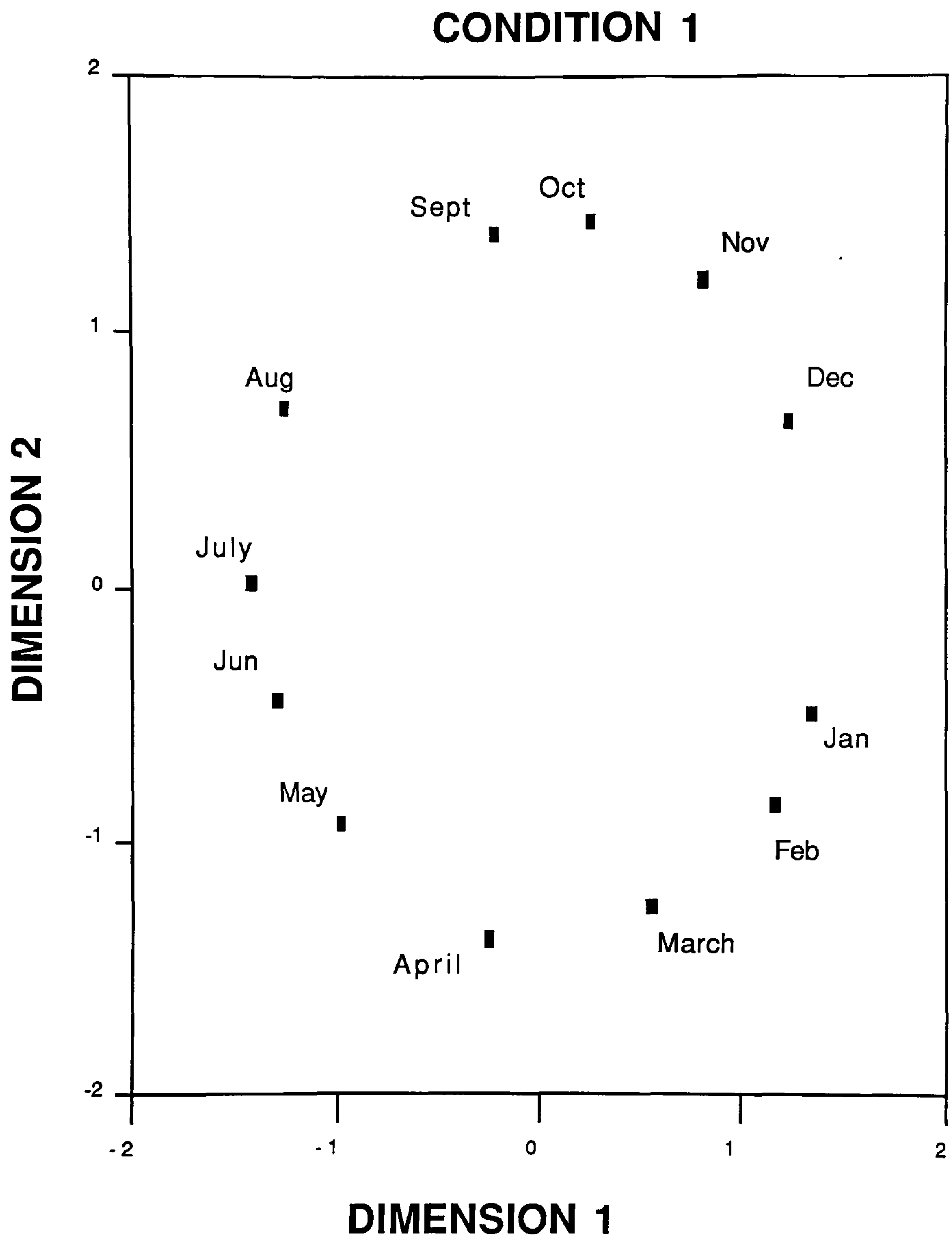

Figure 4.1 The multidimensional scaling stimulus configuration obtained in condition 1 of Experiment 5

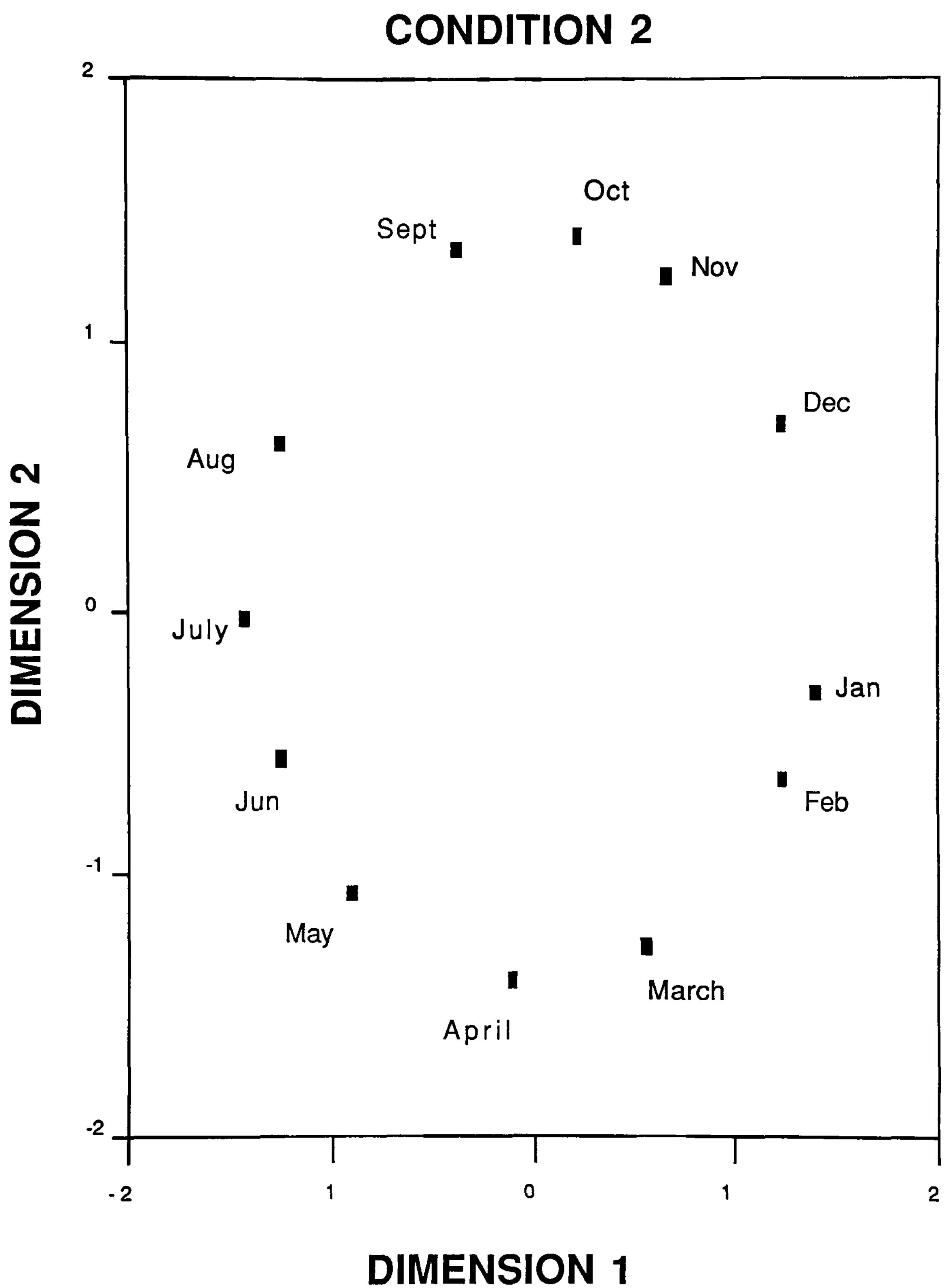

Figure 4.2 The multidimensional scaling stimulus configuration obtained in condition 2 of Experiment 5

perfectly respected.

The similarity structures obtained in the present context differ considerably from those obtained in the symbolic paired-comparison task. This suggests that the characteristics of the months of the year relied upon in performing dissimilarity judgments differed from those relied upon in performing paired-comparisons. In the latter task, the stimulus characteristics which seemed to affect response latencies were the symbolic distance between both members of the stimulus pair, the length of month names, the part of the year in which the months fell, and the presence or absence of end terms in the month pair. The mental representation of the months of the year appears then not to be invariant. It depends on the type of task performed. Our results also indicate the presence of almost identical similarity structures in both conditions of the present experiment. Our manipulation of the form of the presented month names appears then not to have significantly affected subjects' responses.

A multiple linear regression analysis was performed in each condition in order to assess the validity of the above dimensional interpretations. Each of the stimulus characteristics identified above as well as two others were in turn used as the dependent variable and the coordinates of the configuration for each dimension, as the independent variables. Kruskal and Wish (1978), as we pointed out earlier, have proposed this technique as a method of dimensional interpretation. The other two stimulus characteristics considered, corresponded to the length of month names and the exact position of each month in the month series. A consideration of the length of month names enabled us to determine if this stimulus characteristic could affect the overall decision process in the dissimilarity judgment task and if so, if its effect could disappear when month names were presented in an abbreviated form. The exact position of the stimuli in the month series was also considered in order to determine if the order of the months of the year and not only the part of the year in which they fell, affected the decisions.

The independent variables (dimensions 1 and 2) were entered in the equation in a stepwise fashion and the criterion chosen for entry was a significance level of .05. Table 4.1 summarizes the results obtained in both conditions. For each dependent variable (stimulus characteristic), the multiple correlation (R) between this variable and the dimension accounting best for this variable, was given.

The results of this analysis indicated that all four stimulus characteristics were, in both conditions, relatively well fitted by one of the two stimulus dimensions. The temperature associated with each month was, in accord with our visual interpretation, well fitted by the first dimension. The other three stimulus characteristics (the part of the year in which the months fell; the length of month names and; the exact position of the months in the month series) were well fitted by the second dimension. The length of months names was, however, the stimulus characteristic least well fitted by this dimension. The correlation between this characteristic and the second dimension was .77 in Condition 1 and .69 in Condition 2. The correlation between the two other stimulus characteristics and this dimension was not smaller than .82 in both conditions. Furthermore, the part of the year in which the months fell was better fitted by the second dimension than the exact position of the months in the month series, suggesting that subjects' judgments were more sensitive to the part of the year in which the months fell than to the exact position of the months in the month series.

The above results suggest, at first glance, that the length of month names could affect the overall decision process in the dissimilarity judgment task. We do not believe, however, that this stimulus characteristic affected subjects' responses in this task. Note that the three stimulus characteristics identified as accounting for the second dimension are not independent from one another. They are intercorrelated. Hence, the length of month names could be fitted relatively well by the second dimension, even if it did not affect the overall decision process. Furthermore, note that the similarity structure obtained in both conditions of the present experiment, with month names presented in their normal form vs. in abbreviation, were almost identical.

Table 4.1 Results of a multiple linear regression analysis performed as a method of interpretation of the obtained multidimensional scaling solutions.

Condition 1, Experiment 5		
Dependent variable	Dimension	R
Temperature	1	.90
1st/2nd part of year	2	.90
Length of month names	2	.77
Exact order of months	2	.84

Condition 2, Experiment 5		
Dependent variable	Dimension	R
Temperature	1	.89
1st/2nd part of year	2	.85
Length of month names	2	.69
Exact order of months	2	.82

Subjects' introspective reports of the stimulus characteristics relied upon in making their judgments also suggest that the length of month names was not an important stimulus characteristic in the present task. 71% of the subjects in Condition 1 and 73% of the subjects in Condition 2 reported relying mostly or partly on the temperature associated with each month to make their judgments. 36% of the subjects in Condition 1 and 35 % of the subjects in Condition 2 said they also relied on the part of the year in which the months fell in the year in relation with the seasons to make their judgments. 22% of subjects in Condition 1 and 16 % of the subjects in Condition 2 reported they were partly relying on the order of the months in the year or the distance between both months to make their decisions. Inversely, no one said they relied on the length of month names in Condition 1 and only 1 person said she relied on this characteristic to make her judgments in Condition 2.

Finally, although the introspective reports of the subjects of Experiments 1 and 2 were not investigated systematically, several of these subjects spontaneously reported to rely on the length of month names in making their decisions. This stimulus characteristic may have been relied upon in this specific context because when subjects were trying to minimize their response times this stimulus characteristic was perceptually very salient and could serve as a cue for lateness of the month's in the year.

General discussion

This chapter was intended to test the hypothesis according to which the mental representation of months of the year and, consequently, the extent to which specific characteristics of the months of the year will affect the overall decision process, is not invariant but depends on the type of task performed. The similarity structure of the months of the year obtained in a dissimilarity judgment task was examined and compared to that obtained in the symbolic paired-comparison task of Experiments 1 and 2. Our results indicated that this structure differed considerably in both contexts and thus enabled a confirmation of our hypothesis.

Our results are completely in accord with Sergent and Takane's 1987 findings and enable us to conclude that the mental representation of months of the year is context-sensitive and not invariant. Our results also suggest that the length of month names was not a stimulus characteristic affecting subjects' responses in the dissimilarity judgment task. This characteristic was very important in the paired-comparison task because when subjects were going very fast, it was perceptually very salient and could serve as a cue for lateness of the months in the year. However, subjects in the dissimilarity judgment task were not required to perform judgments concerning the earliness or lateness of months in the year and could take as much time as required to make a response.

Although our results enable us to conclude that the mental representation of the months of the year is not invariant, they do not enable us to attribute the differences noted in the similarity structure of the months of the year in the dissimilarity judgment and paired-comparison tasks specifically to the type of task performed or to the performance conditions imposed on the subjects. The two tasks compared differed in two aspects: 1) in the type of response required (dissimilarity judgment vs. earliness/lateness judgment) and 2) in the mode of response required (untimed vs. speeded). Ideally, both tasks should have differed in only one aspect so as to enable us to make more explicit conclusions. Nonetheless, what was important to demonstrate was that the mental representation of the months of the year could differ in certain contexts, that it was not invariant. Our results clearly show this. Furthermore, note that Sergent and Takane (1987) could also be criticized in the same way. Although their two tasks were less different than ours (dissimilarity judgment vs. same-different judgment), they also did differ.

Finally, one interesting comparison that could have been performed is one between the similarity structure obtained in the paired-comparison task with different levels of speed emphasis. Unfortunately, although the emphasis put on speed vs. accuracy was manipulated in Experiments 3 and 4, this comparison could not be performed since only adjacent month pairs were presented in these experiments. An interesting follow-up to the present experiment could thus be one in which the mental representation of the months of the year in the context of the paired-comparison task is examined and compared in different speed emphasis conditions.

CHAPTER V

SUMMARY AND CONCLUSIONS

The present research dealt primarily with the cognitive processes underlying mental comparisons. This research had two main goals. First, it was intended to study the mental representation of a specific overlearned stimulus set, the months of the year, in the context of the symbolic paired-comparison task. Second, it was intended to study the semantic interpretation of positive and negative comparative instructions in this task. Two comparative judgment models, Banks' semantic coding model and Holyoak's reference point model, were extended in order to account for the interpretation of positive and negative instructions. The empirical consequences of different scenarios developed in the context of both models were examined. These scenarios depicted different types of instruction or stimulus recoding at different points in the decision process. A specific prediction concerning the form of the congruity effect obtained with negative instructions when either the sign or the attribute of the instruction was kept constant, was derived from each of these scenarios. Ultimately, the purpose of this research was the identification of the major factors affecting the overall decision process in the symbolic paired-comparison task and, thereby a more thorough understanding of the overall decision process itself.

Two experiments were carried out. They were conducted with French speaking subjects. The instructions chosen were the four forms of the French comparative for temporal order: PLUS TOT "earlier", PLUS TARD "later", MOINS TOT "less early", and

MOINS TARD "less late". For each month pair presented, subjects were required to indicate as rapidly and as accurately as possible which member of the pair occurred earlier, later, less early or less late in the year. In the first experiment, the sign of the instruction was a between-subjects variable, while the polarity of the attribute was a within-subjects variable. Conversely, in the second experiment, the polarity of the attribute was a between-subjects variable, while the sign of the instruction was a within-subjects variable.

The main results that pertained to the mental representation of the months of the year indicated the presence of non-monotone distance effects. These results suggested that our perception of the months of the year is not unidimensional. Groupings based on stimulus characteristics, other than the symbolic distance between both members of the stimulus pair, also occurred in the month series. These specific characteristics influenced both response latencies and accuracy and consequently the form of the reported distance effects. The results of multidimensional scaling and regression analyses indicated, that aside from the symbolic distance, the following stimulus characteristics also affected the overall decision process: 1) the length of month names which could serve as a cue for lateness of the months in the year, 2) the presence or absence of an end term in the month pair (January or December), and 3) the part of the year in which the months fell (first vs. second half). Comparisons were performed much slower when 1) both members of the stimulus pair had names of similar rather than of different length, 2) both months fell in the same rather than in different parts of the year and 3) when the stimulus pair did not contain an end term. The overall form of the obtained congruity effects also confirmed the hypothesis of a multidimensional perception of months of the year in the paired-comparison task.

The main results that pertained to the semantic interpretation of the comparative instruction indicated that negative instructions were more difficult to process than positive instructions only initially. With extended practice, the sign effect could be drastically reduced or even neutralized. Our results also indicated that the form of the congruity effect differed for positive and negative instructions. The form of this effect for negative instructions was, in all conditions, the exact reversal of that obtained with positive instructions. This finding suggested that the strategy used to interpret negative instructions was to recode these statements into their positive equivalent before performing the comparison. This result is consistent with Huttenlocher and her collaborators' (1970; 1971) version of the recoding hypothesis but not with that of Segui and Bertoncini (1978). All negative instructions appeared to have been recoded into their positive equivalent, not only those that included a marked adjective. This result is also compatible only with Banks' and Holyoak's first recoding scenario. The rejection of all other scenarios ruled out the following two strategies as possible ways of interpreting negative instructions: 1) recode the stimulus pair during the comparison process, and 2) perform the comparison as if the instruction was positive and then switch response codes.

Banks' and Holyoak's models could not be evaluated in Experiments 1 and 2 since they essentially did not make different predictions concerning the form of the congruity effect obtained with negative instructions. Two other experiments were then performed in order to further attempt to evaluate these two models. The effect of the relative demands for speed vs. accuracy of responses on the magnitude of the semantic congruity effect was examined. Petrusic and Baranski's (1989) classification of Banks' model as "post-decisional" and of Holyoak's model as "decisional", according to the locus of the congruity effect in each model, enabled a test of these two models. "Decisional" models, only, predicted an effect of the speed/accuracy emphasis manipulation on the magnitude of the congruity effect. An examination of the magnitude of this effect on response times of correct and incorrect responses also enabled another test of Banks' and Holyoak's models. Banks' model predicted larger effects on correct than on incorrect responses while Holyoak's model predicted effects of equal magnitude.

The method we used to manipulate the emphasis put on speed vs. accuracy of responses was a deadline method in conjunction with a payoff matrix. By this method, three different contexts of emphasis on speed vs. accuracy were created: 1) one of extreme speed emphasis (deadline block 1), 2) one of moderate speed emphasis (deadline block 2) and 3) one of extreme accuracy emphasis (deadline block 3).

Our results first indicated that the magnitude of the congruity effect on latency was larger when more emphasis was put on accuracy than on speed or response in both conditions of Experiment 4 ("less early/earlier", "less late/later"). This result suggested that the congruity effect has a "decisional" locus. However, it did not enable a rejection of Banks' model since Petrusic and Baranski's classification could be questioned. Banks' model could have well been classified as "decisional". Our results, nonetheless, clearly supported a decisional locus of the semantic congruity effect.

Our results also indicated that accuracy could, in a context of moderate speed emphasis, reflect variations in the difficulty of the decision process and thus display a congruity effect. Finally, our results showed that correct responses were slower than incorrect responses on deadline blocks 1 and 2 and, consequently, that the magnitude of the congruity effect was more pronounced on correct than on incorrect responses in these two blocks. This result could not be taken as a confirmation of Banks' model since this model's prediction did not take into account the possibility that subjects may use different decisional strategies depending on the requirements for fast vs. accurate decisions. The errors noted in deadline blocks 1 and 2 appeared to reflect the use of fast-guess strategies, whereas those noted in deadline block 3 seemed to reflect the use of accumulative strategies as those depicted in accumulator models.

Experiments 3 and 4 were also intended to eliminate possible problems in the interpretation of the results of Experiments 1 and 2 pertaining to the semantic interpretation of the comparative instruction. The conclusions drawn in the latter two experiments were based solely on differences observed in mean response times or percentages of correct responses for different forms of this instruction. A distinction was not made between decisional processes linked to the choice of a response criterion and those linked to the interpretation of the comparative instruction. We attempted to separate both types of processes and thus obtain a measure of the processing difficulty of the comparative instruction free of bias resulting from variations in the response criteria adopted. Conclusions that pertained to the interpretation of this instruction were now based on changes observed in the form of the function illustrating the tradeoff between speed and accuracy of responses (SAT function) with different forms of the instruction. The data obtained in Experiments 1 and 2 were reanalysed by computing this function for each form of the comparative instruction. The SAT function was also generated in the next two experiments by systematically manipulating the requirements for fast vs. accurate decisions.

An examination of the SAT function· obtained with positive and negative instructions suggested that the sign of the instruction was an important source of decision difficulty only when it was manipulated between-subjects. The sign effect also manifested itself differently depending on whether the requirements for fast vs. accurate decisions were manipulated or not. In Experiment 1, the sign effect was apparent only at the level of the intercept on the x-axis of the SAT function. This result suggested that the sign effect manifested itself during the encoding stage and thus was consistent with the hypothesis of a recoding of negative instructions into their positive equivalent during this encoding stage. In Experiment 3, this effect manifested itself in three different ways: 1) by a larger proportion of fast-guess responses for negative than for positive instructions in deadline block 1, 2) a larger proportion of extremely slow response times for negative than for positive instructions in deadline block 3; 3) by a smaller slope of the SAT function for negative than for positive instructions in deadline block 2. This result suggested that subjects could easily modulate their responses depending on the requirements for fast vs. accurate decisions. They could use different decisional strategies in each deadline block. Hence the sign effect, manifested itself differently in each block.

The results obtained in Experiments 1 and 2 that relate to the mental representation of the months of the year led us to formulate the following hypothesis: the mental representation of the months of the year and, consequently, the extent to which inherent characteristics of the months of the year will affect the overall decision process, is not invariant; it depends on the requirements of the task performed. A fifth experiment was thus carried out. Subjects were presented with month pairs and were required to perform dissimilarity judgments by placing a mark on a linear continuum labelled "very similar" to the left and "very different" to the right. One group of subjects was presented with month names in their usual form while a second group of subjects was presented with month names in an abbreviated form. This manipulation enabled us to determine if the length of month names could in the present task, as in the symbolic paired-comparison task, affect the overall comparison process. Multidimensional scaling analyses were performed in each condition on the dissimilarity ratings. The resulting similarity structures were examined and compared to those obtained in Experiments 1 and 2 in the symbolic paired-comparison task.

Our results indicated first that the similarity structure obtained in both conditions differed considerably from that obtained in Experiments 1 and 2. This result was consistent with Sergent and Takane's (1987) findings and enabled us to conclude that the mental representation of the months of the year is context sensitive and not invariant. Second, our results also suggested that the length of month names was not a stimulus characteristic that affected subjects' performance in the dissimilarity judgment task. This characteristic was very important in the symbolic paired-comparison task because when subjects were going very fast, it was perceptually very salient and could serve as a cue for lateness of the months in the year. However, subjects in the untimed dissimilarity judgment task were not required to perform earliness/lateness judgments and could take as much time as required to make a response.

These results have important practical implications since, as Sergent and Takane (1987) have noted, most previous experiments which studied the similarity structure of various stimulus sets were carried out under conditions different from those prevailing in response time experiments. Yet, findings from the former experiments have often been used to guide the interpretation of the results obtained in the latter experiments and this even though the two types of study may, as we and Sergent and Takane have shown, result in different perceived similarity structures.

We now will, in concluding, suggest two possible future extensions of the present research. The first extension deals with the study of speed/accuracy tradeoffs in mental comparisons. The second extension deals with the study of the mental representation of the months of the year.

First, concerning the study of speed/accuracy tradeoffs in mental comparisons, macro SAT functions instead of micro SAT functions could, in future experiments, be generated. The macro SAT function makes much less stringent assumptions than the micro SAT function. This, of course, implies conducting very large experiments. Generation of the macro SAT function requires, as pointed out by Wood and Jennings (1976), a specialized experimental design involving multiple speed emphasis conditions. However, the quality and quantity of information which can be gained from such a study surpasses considerably that which can be gained from conventional response time studies or those in which micro SAT functions are generated.

The macro SAT function can be generated by means of, for instance, a deadline method. The mean response time and mean percentage of correct responses in each deadline block are first computed. Both values are then plotted one against the other. Several deadline blocks, however, must be used (perhaps from 5 to 10) to enable an examination of the SAT function's three parameters and the formulation of explicit predictions concerning the effect of the independent variable of interest on the form of this function.

The number of replications per subject, session, and stimulus must also be very large so as to enable the generation of separate SAT functions. Ideally, only one source of variation should be present in the SAT functions, that of the independent variable of interest. The curves drawn should represent only one subject, one session and one stimulus. If, however, the stimuli chosen are carefully selected to be of approximately a similar level of difficulty, they could then be pooled together. Each curve will then represent only one subject and session.

Second, concerning the study of the mental representation of the months of the year, another experiment could be performed in which this representation in the context of the paired-comparison task is examined in different speed emphasis conditions. The requirements for fast vs. accurate decisions in each condition could be manipulated by means of, for instance, the deadline method. The form of the symbolic distance effect obtained with each reference month in each speed emphasis condition could then be examined. Such an experiment would enable us to determine more specifically the extent to which the similarity structure of the months of the year varies depending on the requirements for fast vs. accurate decisions. Any difference noted in this structure in the different speed emphasis conditions could then be attributed to the performance conditions imposed on the subjects and not the type of task performed since in all conditions the same type of response would be required, that is, earliness/lateness judgments. Furthermore, this experiment would enable us to determine more specifically the extent to which the length of month names is perceptually salient and thus can serve as cue for lateness of the months in the year, as the emphasis put on speed of responses increases.

Another experiment also could be performed in order to determine the extent to which the length of month names can affect the overall decision process in the symbolic paired-comparison task. The patterns of response times and percentages of correct responses obtained with each reference month could be compared when the month names are presented in a full vs. an abbreviated form.

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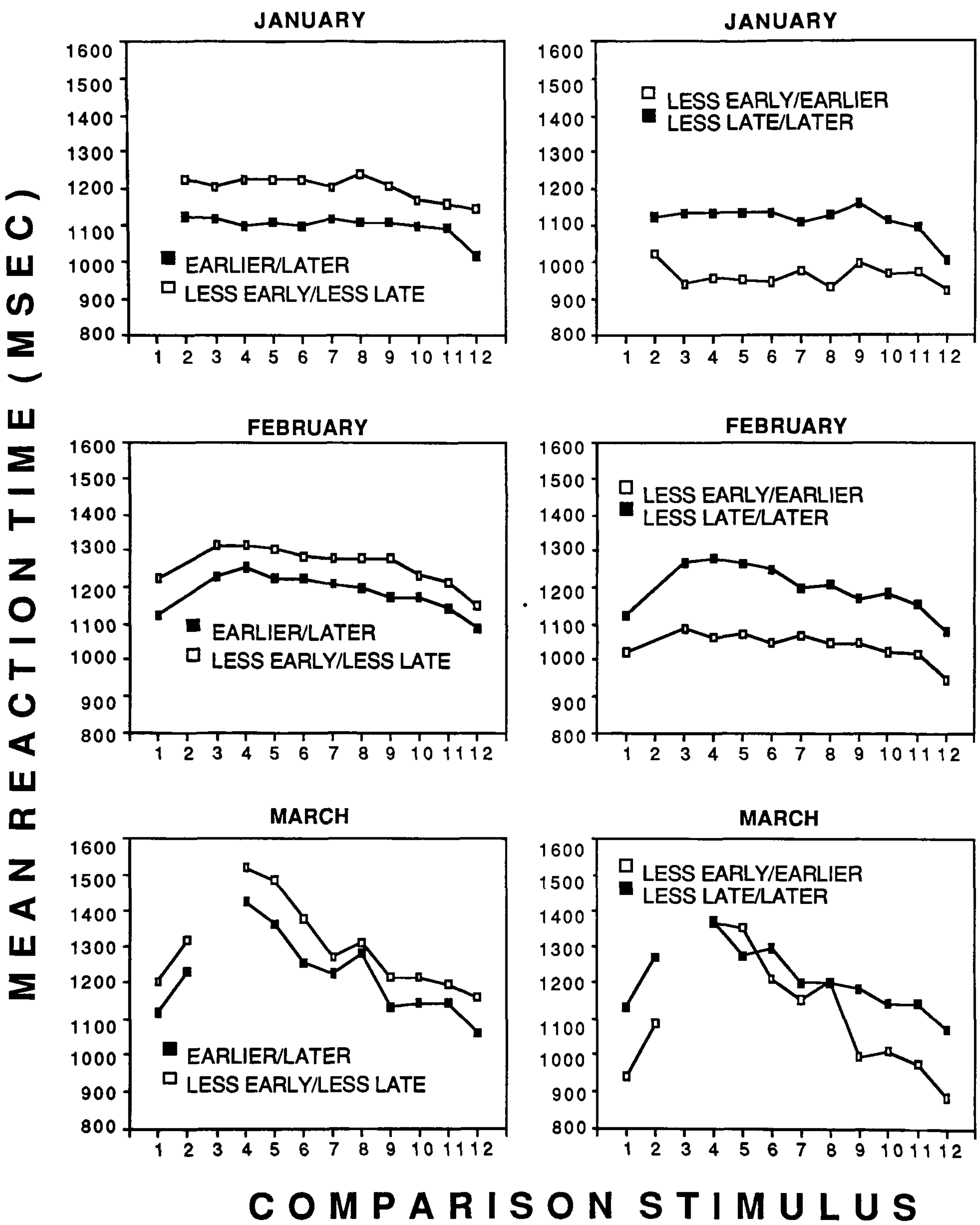
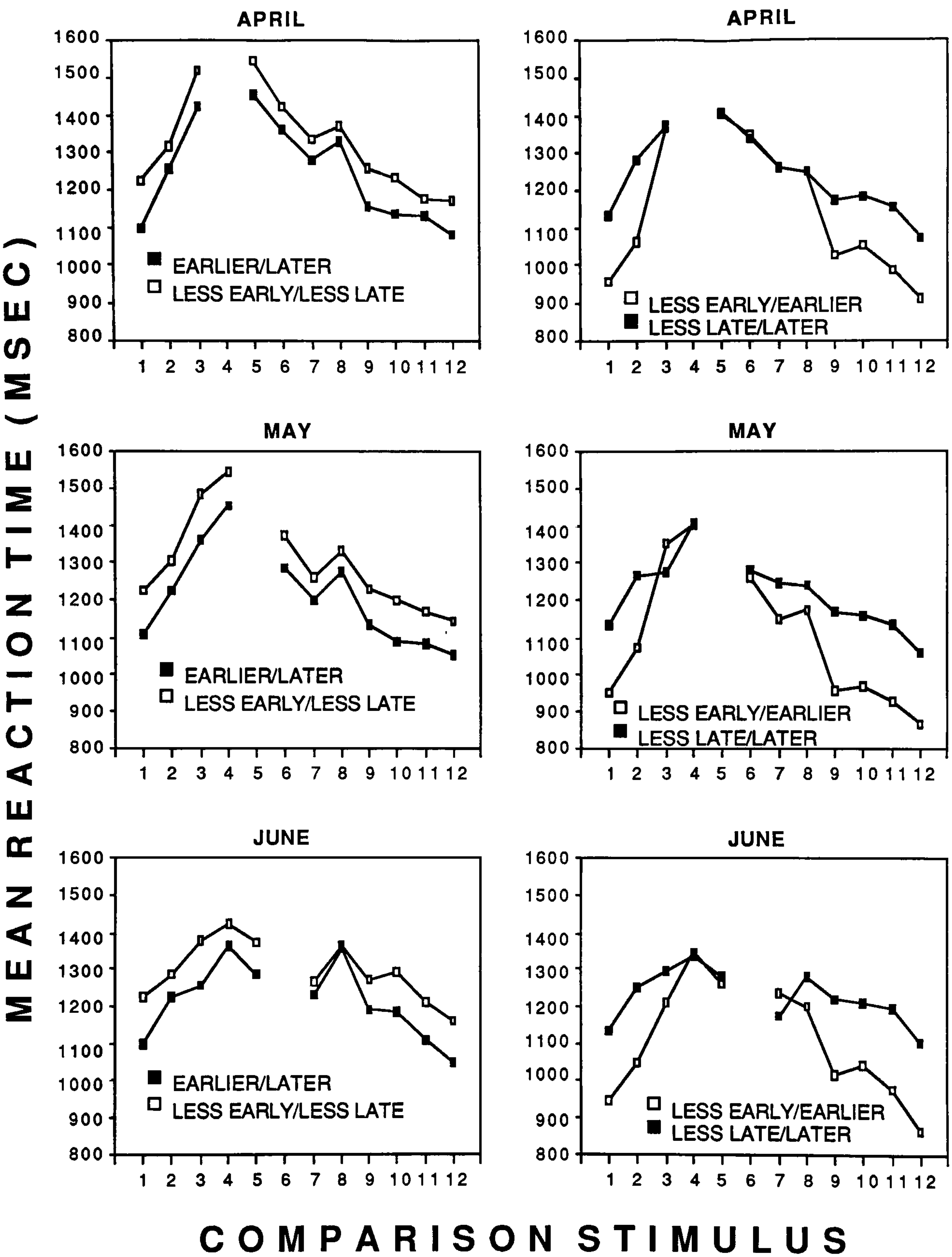
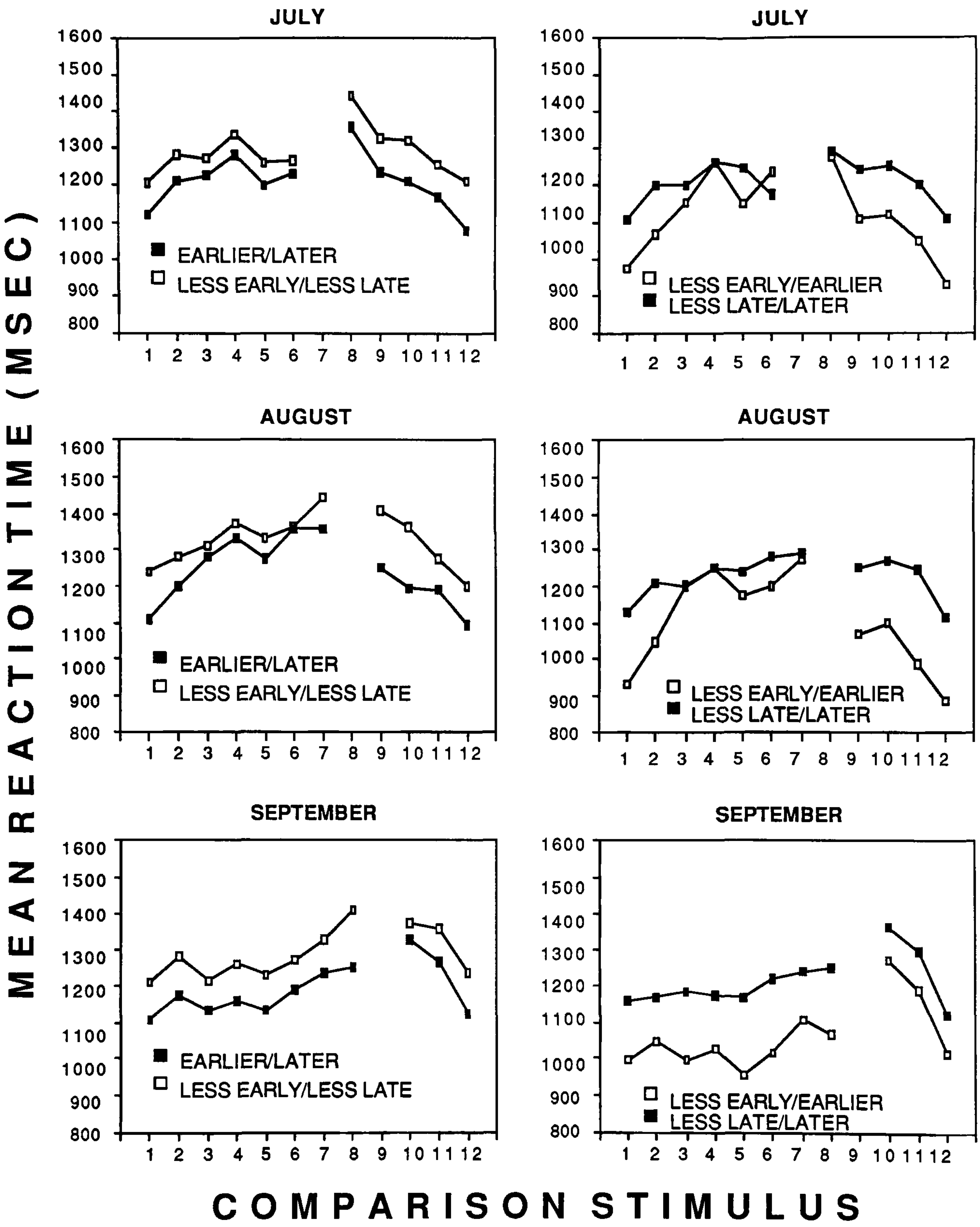
Appendix A. Plots of the symbolic distance effects obtained for each reference month in Conditions 1 and 2 of Experiments 1 and 2



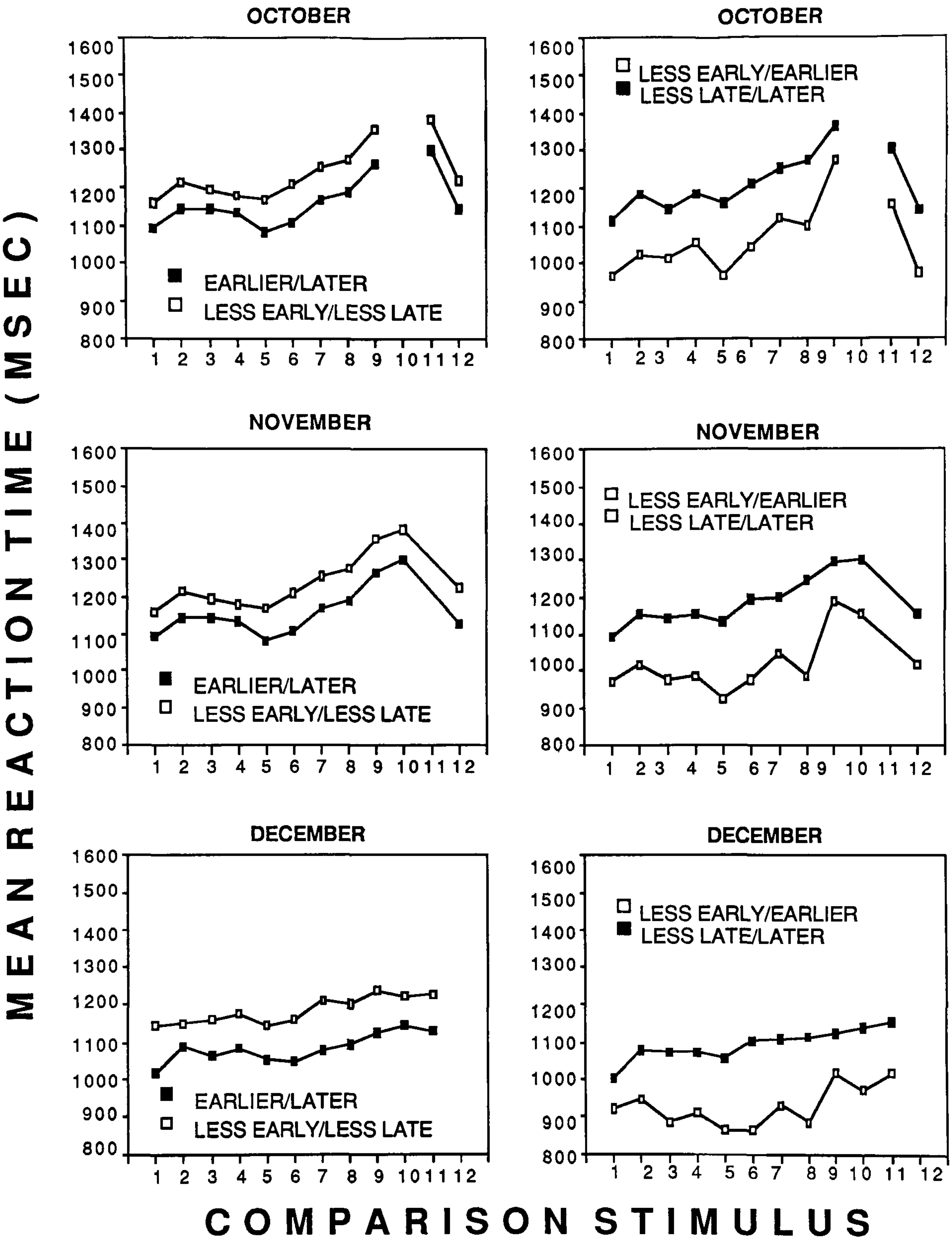
Symbolic distance effects obtained with reference months January, February, and March on mean re latency in conditions 1 and 2 of Experiments 1 (left panel) and 2 (right panel)



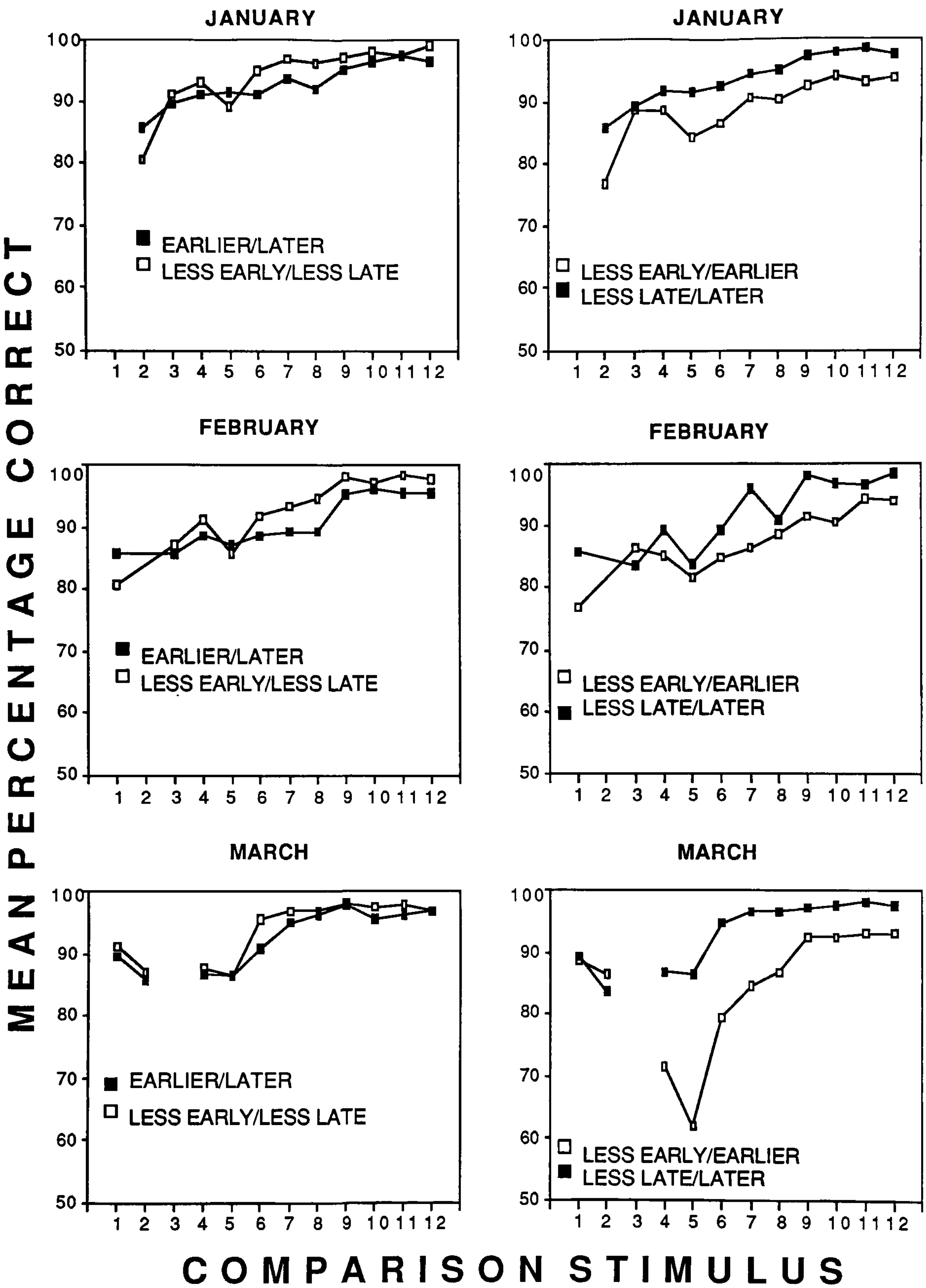
Symbolic distance effects obtained with reference months April, May, and June on mean response la
conditions 1 and 2 of Experiments 1 (left panel) and 2 (right panel)



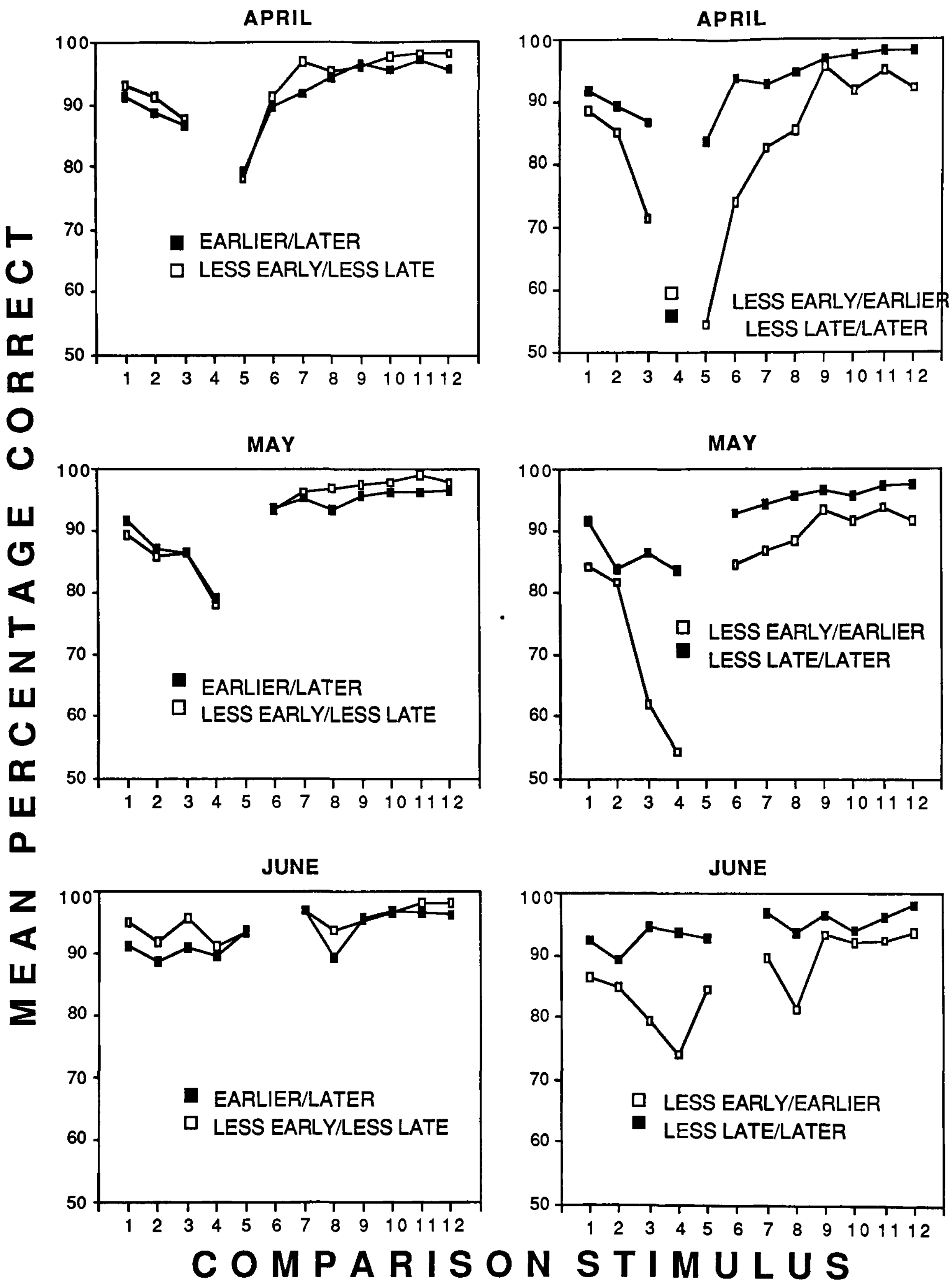
Symbolic distance effects obtained with reference months July, August, and September on mean resp latency in conditions 1 and 2 of Experiment 1 (left panel) and 2 (right panel)



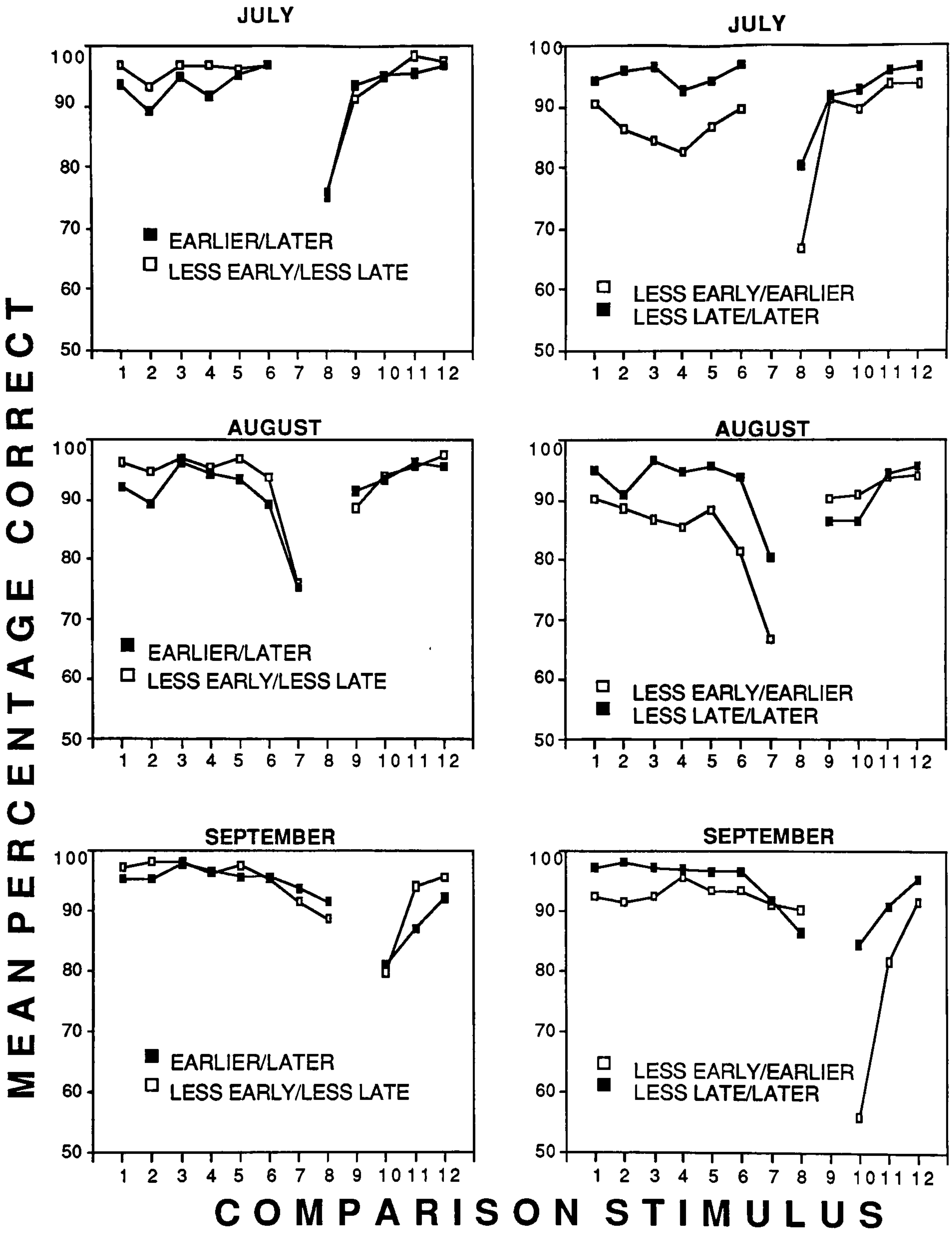
Symbolic distance Effects obtained with reference months October, November, and December on mea response latency in conditions 1 and 2 of Experiments 1 (left panel) and 2 (right panel)



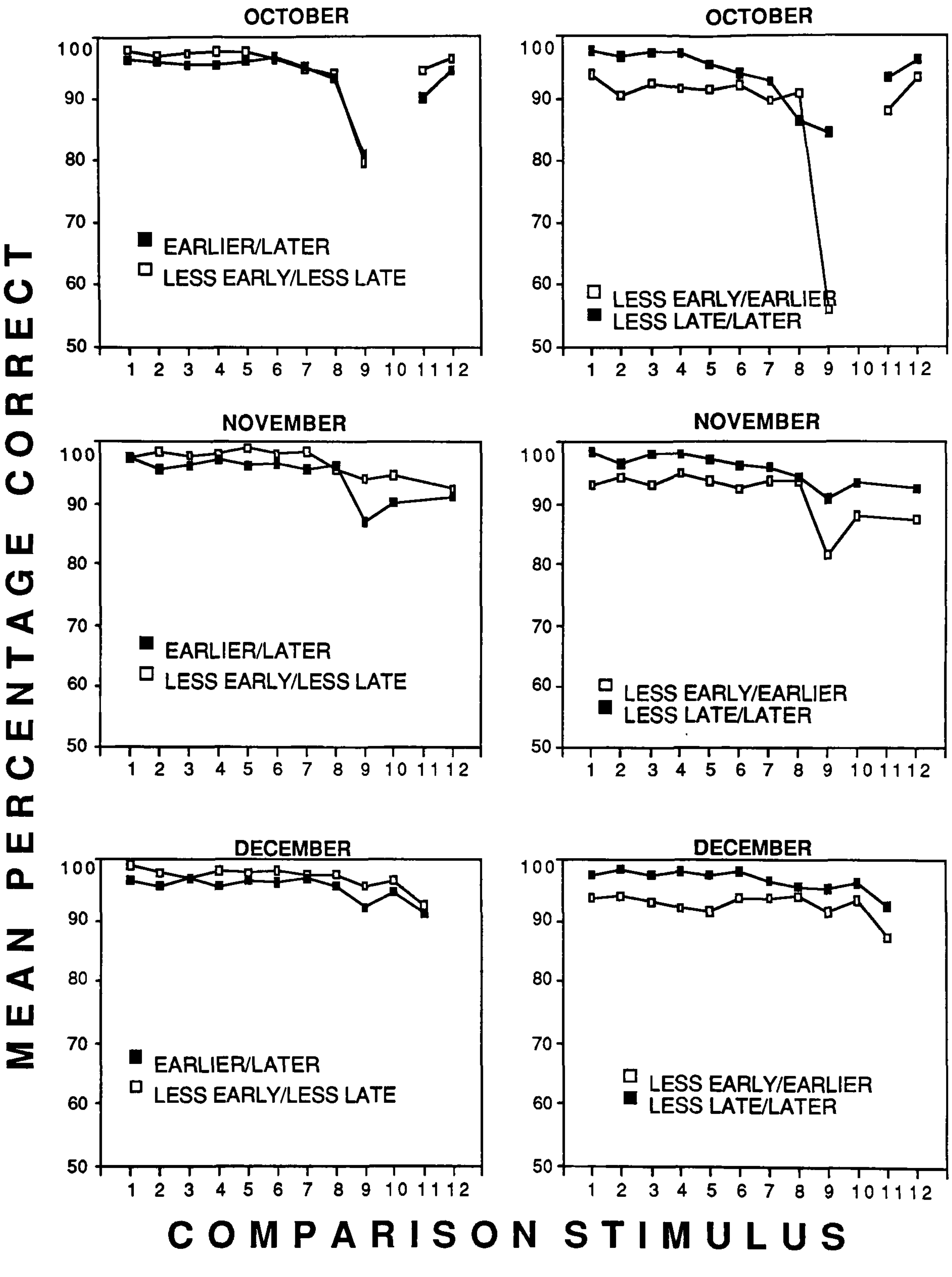
Symbolic distance effects obtained with reference months January, February, and March on mean percentages of correct responses in conditions 1 and 2 of Experiments 1 (left panel) and 2 (right panel)



Symbolic distance effects obtained with reference months April, May, and June on mean percentages of correct responses in conditions 1 and 2 of Experiments 1(left panel) and 2 (right panel)



Symbolic distance effects obtained with reference months July, August and September on mean p correct responses in conditions 1 and 2 of Experiments 1 (left panel) and 2 (right panel)



Symbolic distance effects obtained with reference months October, November, and December on mean percentages of correct responses in conditions1 and 2 of Experiments 1(left panel) and 2 (right panel)

Appendix B. Tables of ANOVAs: The symbolic distance effect for each reference month in Experiments 1 and 2

The symbolic distance effect: Results of an analysis of variance performed in Experiment 1 for each reference month separately with one repeated measure (symbolic distance) and one between-subjects factor (condition).

Reference month		Response latency	Response accuracy
January	Dist	$F(5,14)=0.32$, $p<.89$	$F(5,14)=3.96$, $p<.019$
	D X Co	$F(5,14)=1.32$, $p<.313$	$F(5,14)=1.26$, $p<.33$
February	Dist	$F(5,14)=2.73$, $p<.063$	$F(5,14)=4.61$, $p<.011$
	D X Co	$F(5,14)=0.33$, $p<.885$	$F(5,14)=1.66$, $p<.21$
March	Dist	$F(5,14)=12.3$, $p<.0001$	$F(5,14)=5.09$, $p<.007$
	D X Co	$F(5,14)=1.45$, $p<.267$	$F(5,14)=1.34$, $p<.31$
April	Dist	$F(5,14)=12.5$, $p<.0001$	$F(5,14)=9.64$, $p<.0001$
	D X Co	$F(5,14)=0.47$, $p<.794$	$F(5,14)=1.18$, $p<.37$
May	Dist	$F(5,14)=16.6$, $p<.0001$	$F(5,14)=10.3$, $p<.0001$
	D X Co	$F(5,14)=0.55$, $p<.738$	$F(5,14)=0.60$, $p<.7$
June	Dist	$F(5,14)=14.9$, $p<.0001$	$F(5,14)=3.16$, $p<.04$
	D X Co	$F(5,14)=0.74$, $p<.605$	$F(5,14)=1.35$, $p<.3$
July	Dist	$F(5,14)=11.8$, $p<.0001$	$F(5,14)=3.54$, $p<.028$
	D X Co	$F(5,14)=0.69$, $p<.637$	$F(5,14)=0.77$, $p<.59$
August	Dist	$F(5,14)=11.3$, $p<.0001$	$F(5,14)=9.67$, $p<.0001$
	D X Co	$F(5,14)=0.72$, $p<.618$	$F(5,14)=0.92$, $p<.5$
Sept	Dist	$F(5,14)=25.8$, $p<.0001$	$F(5,14)=7.50$, $p<.001$
	D X Co	$F(5,14)=0.07$, $p<.995$	$F(5,14)=2.12$, $p<.12$
Oct	Dist	$F(5,14)=13.1$, $p<.0001$	$F(5,14)=4.94$, $p<.008$
	D X Co	$F(5,14)=0.37$, $p<.862$	$F(5,14)=0.90$, $p<.51$
Nov	Dist	$F(5,14)=11.6$, $p<.0001$	$F(5,14)=4.68$, $p<.01$
	D X Co	$F(5,14)=0.08$, $p<.995$	$F(5,14)=0.98$, $p<.46$
Dec	Dist	$F(5,14)=4.97$, $p<.008$	$F(5,14)=2.74$, $p<.06$
	D X Co	$F(5,14)=1.02$, $p<.441$	$F(5,14)=0.44$, $p<.82$

The symbolic distance effect: Results of an analysis of variance performed in Experiment 2 for each reference month separately with one repeated measure (symbolic distance) and one between-subjects factor (condition).

Reference month		Response latency	Response accuracy
January	Dist	$F(5,14)=6.72$, $p<.002$	$F(5,14)=3.62$, $p<.026$
	D X Co	$F(5,14)=8.78$, $p<.001$	$F(5,14)=1.51$, $p<.25$
February	Dist	$F(5,14)=12.9$, $p<.0001$	$F(5,14)=2.20$, $p<.112$
	D X Co	$F(5,14)=4.98$, $p<.008$	$F(5,14)=1.07$, $p<.42$
March	Dist	$F(5,14)=24.9$, $p<.0001$	$F(5,14)=4.38$, $p<.013$
	D X Co	$F(5,14)=2.94$, $p<.051$	$F(5,14)=4.47$, $p<.01$
April	Dist	$F(5,14)=12.5$, $p<.0001$	$F(5,14)=7.81$, $p<.001$
	D X Co	$F(5,14)=8.39$, $p<.001$	$F(5,14)=4.24$, $p<.02$
May	Dist	$F(5,14)=23.1$, $p<.0001$	$F(5,14)=6.78$, $p<.002$
	D X Co	$F(5,14)=8.33$, $p<.001$	$F(5,14)=3.57$, $p<.03$
June	Dist	$F(5,14)=18.7$, $p<.0001$	$F(5,14)=4.48$, $p<.012$
	D X Co	$F(5,14)=3.94$, $p<.019$	$F(5,14)=4.26$, $p<.02$
July	Dist	$F(5,14)=5.04$, $p<.008$	$F(5,14)=4.24$, $p<.015$
	D X Co	$F(5,14)=6.03$, $p<.004$	$F(5,14)=0.67$, $p<.65$
August	Dist	$F(5,14)=7.68$, $p<.001$	$F(5,14)=5.45$, $p<.005$
	D X Co	$F(5,14)=12.9$, $p<.0001$	$F(5,14)=1.84$, $p<.17$
Sept	Dist	$F(5,14)=32.8$, $p<.0001$	$F(5,14)=7.82$, $p<.001$
	D X Co	$F(5,14)=9.36$, $p<.0001$	$F(5,14)=3.99$, $p<.02$
Oct	Dist	$F(5,14)=20.9$, $p<.0001$	$F(5,14)=5.13$, $p<.007$
	D X Co	$F(5,14)=10.8$, $p<.0001$	$F(5,14)=1.68$, $p<.2$
Nov	Dist	$F(5,14)=18.4$, $p<.0001$	$F(5,14)=2.55$, $p<.077$
	D X Co	$F(5,14)=15.9$, $p<.0001$	$F(5,14)=1.82$, $p<.17$
Dec	Dist	$F(5,14)=8.46$, $p<.001$	$F(5,14)=2.24$, $p<.108$
	D X Co	$F(5,14)=4.23$, $p<.015$	$F(5,14)=0.58$, $p<.72$

Appendix C. Estimates of the size of the distance effect obtained with each reference month in Experiments 1 and 2

Estimates of the size of the distance effect obtained with each reference month in Experiments 1 and 2. Statistic used: Partial eta squared.

Reference month	Experiment 1		Experiment 2	
	Response Latency	Response Accuracy	Response Latency	Response Accuracy
January	.02	.41	.40	.28
February	.19	.27	.40	.19
March	.56	.51	.64	.28
April	.70	.57	.64	.51
May	.72	.55	.69	.51
June	.67	.33	.65	.27
July	.59	.43	.56	.34
August	.44	.52	.44	.32
Sept	.58	.61	.59	.53
October	.60	.49	.55	.49
Nov	.53	.40	.65	.22
Dec	.26	.29	.43	.23

Appendix D. Tests of simple main effects: The Symbolic distance by Condition interaction in Experiment 2

The Symbolic distance effect in both conditions of Experiment 2: Results of simple main effect tests performed on response latency for each reference month separately.

Reference month	Condition	Response latency
January	1	$F(5,90)=3.50$,$p<.006$
	2	$F(5.90)=15.24$, $p<.0001$
February	1	$F(5,90)=0.46$, $p<.805$
	2	$F(5,90)=18,86$, $p<.0001$
March	1	$F(5,90)=23.09$, $p<.0001$
	2	$F(5,90)=13.52$, $p<.0001$
April	1	$F(5,90)=38.48$, $p<.0001$
	2	$F(5,90)=8.71$, $p<.0001$
May	1	$F(5,90)=44.97$, $p<.0001$
	2	$F(5,90)=6.47$, $p<.0001$
June	1	$F(5,90)=36.53$, $p<.0001$
	2	$F(5,90)=5.97$, $p<.0001$
July	1	$F(5,90)=19.05$, $p<.0001$
	2	$F(5,90)=6.87$, $p<.0001$
August	1	$F(5,90)=9.34$, $p<.0001$
	2	$F(5,90)=9.78$, $p<.0001$
September	1	$F(5,90)=19.96$, $p<.0001$
	2	$F(5,90)=11.11$, $p<.0001$
October	1	$F(5,90)=17.50$, $p<.0001$
	2	$F(5,90)=10.16$, $p<.0001$
November	1	$F(5,90)=32.72$, $p<.0001$
	2	$F(5,90)=15.50$, $p<.0001$
December	1	$F(5,90)=18.11$, $p<.0001$
	2	$F(5,90)=1.44$, $p<.217$

The Symbolic distance effect in both conditions of Experiment 2: Results of simple main effect tests performed on response accuracy for each reference month separately.

Reference month	Condition	Response latency
January	1	F(5,90)=6.73 ,p<.0001
	2	F(5.90)=1.83, p<.115
February	1	F(5,90)=2.52, p<.035
	2	F(5,90)=2.23, p<.058
March	1	F(5,90)=9.26, p<.0001
	2	F(5,90)=1.61, p<.164
April	1	F(5,90)=25.98, p<.0001
	2	F(5,90)=1.30, p<.27
May	1	F(5,90)=25.98, p<.0001
	2	F(5,90)=1.80, p<.121
June	1	F(5,90)=10.33, p<.0001
	2	F(5,90)=2.42, p<.042
July	1	F(5,90)=7.88, p<.0001
	2	F(5,90)=2.33, p<.048
August	1	F(5,90)=7.62, p<.0001
	2	F(5,90)=2.53, p<.034
September	1	F(5,90)=24.52, p<.0001
	2	F(5,90)=2.35, p<.047
October	1	F(5,90)=19.88, p<.0001
	2	F(5,90)=2.04, p<.081
November	1	F(5,90)=6.98, p<.0001
	2	F(5,90)=2.00, p<.086
December	1	F(5,90)=3.78, p<.004
	2	F(5,90)=1.98, p<.089

Appendix E. Questionnaire of Experiment 5[16]

[16] Note that the length of the linear segments in the following questionnaire is a bit smaller than 10.2 centimetres. This is due to the type of font used to print the text. The length of the linear segments in the original questionnaires was exactly 10.2 centimetres.

Introduction

Nous vous demandons de bien vouloir remplir ce questionnaire. N'inscrivez pas votre nom car le questionnaire doit demeurer anonyme. Notez qu'il n'y a pas de bonnes ou mauvaises réponses. Nous nous intéressons à vos opinions personnelles, et personne n'a exactement les mêmes opinions.

Votre tâche consiste à évaluer la similarité qui peut exister entre chacun des douze mois de l'année. Réflichissez d'abord à chacun des douze mois et pensez aux caractéristiques qui sont propres à chacun d'eux.

Vous aurez à comparer 66 paires de mois. Pour chacune des comparaisons vous aurez à indiquer jusqu'à quel point les deux mois de l'année sont similaires.

Exprimez votre opinion en mettant un trait entre les pôles "très similaires" et "très différents" du continuum de similarité (tel qu'illustré ci-dessous). Plus le trait est placé près du pôle "très similaire", plus les deux mois sont jugés comme étant similaires. Et, plus le trait est placé près du pôle "très différents", plus les deux mois sont jugés comme étant différents.

______________________________/_________

Très similaires Très différents

1. AVRIL AOUT

Très similaires ____________________ Très différents

2. JUILLET AOUT

Très similaires ____________________ Très différents

3. MAI AOUT

Très similaires Très différents

4. AVRIL MAI

Très similaires Très différents

5. FEVRIER MAI

Très similaires Très différents

6. NOVEMBRE DECEMBRE

Très similaires Très différents

7. AOUT NOVEMBRE

____

Très similaires Très différents

8. MARS OCTOBRE

____

Très similaires Très différents

9. OCTOBRE NOVEMBRE

Très similaires Très différents

10. MARS NOVEMBRE

Très similaires Très différents

11. FEVRIER AVRIL

Très similaires Très différents

12. JANVIER DECEMBRE

Très similaires Très différents

13. MAI JUILLET

Très similaires Très différents

14. JUILLET OCTOBRE

Très similaires Très différents

15. AVRIL JUILLET

Très similaires Très différents

16. MARS SEPTEMBRE

Très similaires Très différents

17. JANVIER NOVEMBRE

Très similaires Très différents

18. AVRIL OCTOBRE

Très similaires Très différents

19. AVRIL DECEMBRE

____

Très similaires Très différents

20. SEPTEMBRE OCTOBRE

____

Très similaires Très différents

21. FEVRIER NOVEMBRE

Très similaires ______________________ Très différents

22. JUIN OCTOBRE

Très similaires ______________________ Très différents

23. AOUT DECEMBRE

Très similaires ____________________ Très différents

24. MAI NOVEMBRE

Très similaires ____________________ Très différents

25. MARS JUILLET

Très similaires ______________________________ Très différents

26. AVRIL NOVEMBRE

Très similaires ______________________________ Très différents

27. JANVIER JUIN

Très similaires Très différents

28. JUIN JUILLET

Très similaires Très différents

29. AOUT OCTOBRE

Très similaires ______________________________ Très différents

30. MARS DECEMBRE

Très similaires ______________________________ Très différents

31. JUIN DECEMBRE

Très similaires Très différents

32. FEVRIER MARS

Très similaires Très différents

33. JANVIER OCTOBRE

Très similaires Très différents

34. JUIN SEPTEMBRE

Très similaires Très différents

35. FEVRIER JUILLET

Très similaires ______________________________ Très différents

36. SEPTEMBRE DECEMBRE

Très similaires ______________________________ Très différents

37. MAI OCTOBRE

Très similaires ______________________________ Très différents

38. MAI JUIN

Très similaires ______________________________ Très différents

39. MARS JUIN

____

Très similaires Très différents

40. JANVIER JUILLET

____

Très similaires Très différents

41. JUIN AOUT

Très similaires Très différents

42. JUILLET DECEMBRE

Très similaires Très différents

43. MARS AOUT

Très similaires Très différents

44. JANVIER MARS

Très similaires Très différents

45. FEVRIER SEPTEMBRE

Très similaires Très différents

46. JANVIER SEPTEMBRE

Très similaires Très différents

47. JANVIER AVRIL

Très similaires Très différents

48. AOUT SEPTEMBRE

Très similaires Très différents

49. JANVIER FEVRIER

Très similaires Très différents

50. JUILLET SEPTEMBRE

Très similaires Très différents

51. AVRIL JUIN

Très similaires Très différents

52. JUIN NOVEMBRE

Très similaires Très différents

53. JANVIER AOUT

Très similaires ________________________________ Très différents

54. MAI DECEMBRE

Très similaires ________________________________ Très différents

55. FEVRIER AOUT

Très similaires Très différents

56. AVRIL SEPTEMBRE

Très similaires Très différents

57. MARS AVRIL

Très similaires ____ Très différents

58. JUILLET NOVEMBRE

Très similaires ____ Très différents

59. SEPTEMBRE NOVEMBRE

Très similaires Très différents

60. MAI SEPTEMBRE

Très similaires Très différents

61. FEVRIER JUIN

Très similaires ____________________ Très différents

62. MARS MAI

Très similaires ____________________ Très différents

63. OCTOBRE DECEMBRE

Très similaires ______________________________ Très différents

64. FEVRIER OCTOBRE

Très similaires ______________________________ Très différents

65. JANVIER MAI

Très similaires ____________________ Très différents

66. FEVRIER DECEMBRE

Très similaires ____________________ Très différents

Informations diverses

S'il vous plaît, répondez aux questions suivantes:

1. Votre date de naissance Jour _______ mois ______ année _____
2. Sexe ___
3. Programme universitaire ______________________________
4. Année universitaire 1ière _________ 2ième _____ 3ième _____ 4ième _____
5. Votre langue maternelle ______________________________
6. Sur quelles caractéristiques des mois de l'années vous êtes vous basées pour effectuer vos jugements de similarités?

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MERCI DE VOTRE PARTICIPATION