RICE UNIVERSITY

CONGRUENCY EFFECTS WITH DYNAMIC AUDITORY STIMULI

by

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A THESIS SUBMITTED
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE
MASTER OF ARTS

APPROVED, THESIS COMMITTEE

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April, 1997

ABSTRACT

Congruency Effects with Dynamic Auditory Stimuli

by

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As auditory displays become more common it is increasingly important to understand the perception of complex and dynamic auditory stimuli and how the information contained in the various dimensions of these stimuli influences performance. In the present study listeners made keypress responses to dynamic sound stimuli which started high or low in pitch and became higher or lower in pitch during each trial. The results showed that pitch and pitch change interacted in an asymmetrical manner, with pitch information intruding more on judgments of pitch change than vice versa. Neither pitch nor pitch change interacted with vertically arranged responses to produce the strong spatial S-R compatibility effects that were expected based on previous research and on descriptions of pitch in everyday language. Analytic versus holistic listening strategies or the physical location of the sounds may affect interactions of the stimuli and responses in this type of selective listening task.

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INTRODUCTION

Performing many types of tasks in a variety of real-world settings requires selective attention to just one dimension of a stimulus. For example, in order to avoid a collision a pilot might need to make a speeded response based on the proximity of an oncoming plane, ignoring, for the moment at least, the size or color of it. The increasing use of auditory displays means that a growing number of professionals, from pilots, to surgeons, to control room engineers, must rely on sounds emitted in their environment, by their tools and even from communications devices to guide their actions. In order to design auditory interfaces which afford better comprehension and elicit faster and more accurate reactions, one must first understand how different attributes of auditory stimuli interact to influence perception and responding. One major question is whether it is possible to attend selectively to a given dimension of a sound, while ignoring other dimensions of the sound. For example, a Geiger counter operator may need to listen specifically to the temporal pattern of the sound, which indicates the prevalence of radioactive particles, and ignore changes in the pitch of the sound, which may indicate the type of particles that are present. On the other hand, in monitoring a landing approach an air traffic controller may need to attend to the rate of pitch change that represents rate of descent of an airplane, while paying less attention to the absolute pitch of the sound, which represents the actual altitude of the plane.

Design of any sort of control apparatus also requires an understanding of how the displayed stimulus features interact with the attributes of the response set. For example, it has been shown that when using left and right buttons to respond to a light which may appear on the left or on the right side of a display, faster responses result when the left light is paired with the left button and the right light is paired with the right button, rather than the opposite assignment of lights to buttons (e.g., Proctor & Reeve, 1990). Simple high-pitched sounds may also afford faster responding than low-pitched sounds, if the response is an upward motion of a switch. This high-pitch advantage for upward responses may not apply for other response devices, such as the left and right buttons mentioned in the previous example, or for stimuli that do not remain constant. In addition, the influence of pitch on responding may depend on how the other attributes of the sound, such as its tempo, timbre or loudness, are related to the response set.

Stimulus-Stimulus Interactions

When the correctness of a response depends on selectively attending to one dimension of a sound, and ignoring the other stimulus dimensions, performance will depend on how the individual dimensions of the sound are perceived and how different dimensions combine to influence performance. Of the various attributes of sound that may be used to display information, pitch is of primary interest because it is the dimension most commonly used to represent data in auditory displays. In particular, it is important to know how pitch interacts with dynamic changes in the stimulus (including changes in pitch itself) because the auditory representation of data rarely involves single, static values (i.e., unchanging pitches). For this reason, it is important to understand how pitch is perceived, how pitch interacts with other stimulus dimensions to affect responding in selective listening tasks and how these interactions affect responses to dynamic auditory stimuli.

The present research explores the effects of pitch change on pitch classification, as well as the effects of relative pitch on the classification of pitch change. In addition this research examines some of the effects of the nature of the response set and the assignment of particular stimuli to particular responses.

Pitch perception. The perception of pitch has been studied extensively. There is a wealth of research exploring the physics of sound and the mechanisms of hearing (e.g., Moore, 1989), the psychophysical aspects of perception and discrimination of different pitches (e.g., Bregman, 1990; Moore, 1989; Stevens, 1957), how pitch fits into the structure of music (e.g., Révész, 1954) and the psychological aspects of hearing, pitch and music perception (e.g., Deutsch, 1982). Pitch is often used as a dimension in auditory displays for the very reason that so much is already known about simple pitch perception. In addition, most listeners are familiar with the concept of pitch and can detect fairly small pitch changes with little training (e.g., 1-Hz change in a pure tone of 1000 Hz; Moore, 1989). Another reason for using pitch as a display dimension is the relative ease with which pitch can be controlled by current display hardware (Kramer, 1994). Pitch also more evenly represents a wider range of values than, say, loudness, since at the extremes loudness does not provide an effective display dimension (as soft sounds are masked by ambient noise, and loud sounds are potentially disturbing or even damaging).

Pitch in interaction with other dimensions. Relatively little is known about how pitch interacts with other stimulus dimensions and how successful listeners can be at attending to just one of several auditory stimulus dimensions. For many pairs of stimulus dimensions subjects are able to respond solely on the basis of the information contained in the relevant or “cue” dimension, and successfully ignore the other, “irrelevant” dimension. However, for other pairs subjects are not able to attend selectively to one dimension. Rather, performance is disrupted by variations in the other dimension. An example of how pitch can affect perception of another stimulus dimension is Melara and Marks' (1990) finding that listeners responded faster to a loud sound if the sound was also high, rather than low in pitch—despite instructions to ignore the pitch. Correspondingly, responses to soft sounds were faster if the pitch was low, rather than high. Other studies have demonstrated interactions of pitch with other auditory dimensions, including loudness (e.g., Grau & Kemler Nelson, 1988; Marks, 1982; Melara, Marks & Lesko, 1992; Stevens, 1935), timbre (e.g., Melara & Marks, 1990), waveform and duration (e.g., Walker, 1987) and the physical location of the sound (e.g., Simon and Rudell, 1967).

Cross-modality matching studies have demonstrated that pitch also interacts with some non-auditory stimulus dimensions including the brightness of lights (high↔bright), the brightness of colors (high↔white), the “sharpness” of shapes (high↔sharp; Marks, 1987), and the spatial location of a visual object (high pitch↔high location of a visual target; Melara & O'Brien, 1990).

Dynamic stimuli and congruency effects. To date, virtually all of the research on interactions of pitch with other stimulus dimensions has involved an unchanging pitch and another static stimulus dimension. Thus, there is still much to be learned about dynamic auditory stimuli, and, in particular, about how changing pitch plays a role in perceiving and making responses to other aspects of a sound. Recent findings with dynamic visual stimuli suggest that changes within a stimulus dimension may interact with responding to a given value of that same stimulus dimension. For instance, it has been shown that perception of the physical position of a visual target is influenced by the direction of motion of the target, even when the task is to respond to, for example, onset position and ignore the motion of the target (e.g., Ehrenstein, 1994; Michaels, 1988; 1993; Proctor, Van Zandt, Lu & Weeks, 1993). In the case where the task is to attend selectively to the onset position of a visual target (i.e., whether a square appears on the left or the right side of the display), responses are typically faster if the position (e.g., left) is congruent with the direction of motion of the same visual target (e.g., the square moves farther to the left). Responses are slower if the position and direction of movement are incongruent (i.e., the square appears on the left, but moves toward the right side of the display; Ehrenstein, 1994; Proctor et al., 1993). It remains to be seen whether, in the auditory domain, the interaction of pitch and pitch change produce similar congruency effects, so that if a sound is high in pitch, responding is faster if the sound becomes higher in pitch than if it becomes lower in pitch, and vice versa.

Stimulus-Response Interactions

In addition to studying how one attribute of an auditory stimulus affects perception of another attribute of the same (or different) stimulus, much research has been conducted in an attempt to understand how the information contained in a stimulus dimension affects the selection of an appropriate response to that information. Research has shown that different assignments of stimuli to responses can result in different performance for a task. Although most studies in this area have considered the stimulus-response (S-R) assignment for one dimension of the stimulus, it has also been found that the correspondence between a second, irrelevant dimension (i.e., one that was supposed to be ignored) and the response set can affect response time and accuracy, depending on how the irrelevant dimension is related to the response set. The following sections discuss some of the effects that can result from different assignments of either task-relevant or task-irrelevant stimulus dimensions to responses.

Stimulus-response compatibility effects. In general, S-R compatibility effects refer to the differences in reaction time (RT) and accuracy obtained under different assignments of a single dimension of a stimulus to the allowable responses in a task (e.g., Fitts & Seeger, 1953; Proctor & Reeve, 1990; see also Simon, 1990). These effects are described as *spatial* compatibility effects when they arise as a result of the correspondence of a spatial attribute of the stimulus to spatially arranged responses (e.g., Fitts & Deininger, 1954; Fitts & Seeger, 1953; Proctor & Reeve, 1990). For example, if the task is to press one of two vertically arranged response keys when one of two vertically arranged lights is turned on, responses will be faster if the upper light is assigned to the upper key, and the lower light is assigned to the lower key (the compatible S-R assignment), than when the upper light is assigned to the lower key and the lower light is assigned to the upper key (the incompatible assignment; see Proctor & Reeve, 1990, for an overview). Spatial compatibility effects have also been found for auditory stimuli. For example, the spatial location of a sound (i.e., whether it is presented via the upper or lower of two speakers) can interact with vertically arranged responses, such that keypresses are faster if the response is to press the upper key when a sound is presented from the upper speaker, compared to when the response is to press the upper key when the sound is presented from the lower speaker (Simon & Craft, 1970). The S-R assignments that result in faster performance in these cases are considered “compatible”, whereas the S-R assignments that result in slower performance are considered “incompatible”.

Pitch has also been found to result in spatial compatibility effects, in that assigning high pitch to an upper (or upward) response (the compatible assignment) results in faster responding than assigning high pitch to a lower (or downward) response (the incompatible assignment; Simon, Mewaldt, Acosta, & Hu, 1976).

While it was not a study of S-R compatibility effects, per se, Mudd (1963) also found evidence that there are population stereotypes involved in listening and responding to pitch. In his study subjects listened to pairs of sounds, then placed pegs on a pegboard to represent the relative spatial locations that the sounds connoted. Listeners tended to place pegs higher up in the pegboard in response to higher pitched sounds. Thus, it appears from Mudd’s experiment that listeners treated pitch as being correlated with vertical spatial position.

Compatibility effects from to-be-ignored dimensions. Although the majority of S-R compatibility studies have featured spatial attributes of stimuli assigned to spatial response sets, Simon and his colleagues have shown that compatibility effects can also arise from correspondences between the response set and stimulus dimensions that are nominally irrelevant to the task (e.g., Simon, 1990; Simon & Rudell, 1967; see Lu & Proctor, 1995 for a review). For example, if the task is to respond with a left key when the spoken word “left” is heard, and to respond with a right key when the word “right” is heard, while ignoring the ear in which the word is presented, it turns out that the to-be-ignored spatial location of the stimulus (i.e., in which ear the stimulus is presented) affects response time and accuracy. In particular, when the spatial location of the stimulus corresponds to the location of the correct response (based on the relevant cue dimension), responding is faster than if the (supposedly irrelevant) spatial location of the stimulus is opposite to the location of the correct response.

Although first described in a paradigm using spoken words and spatially arranged responses (Simon & Rudell, 1967), such effects of irrelevant stimulus dimensions (commonly called the *Simon effect*) are not limited to auditory stimuli. Similar effects have also been found using visual and cross-modal stimulus dimensions. For example, Craft and Simon (1970) presented red and green lights to the left and right eyes, and instructed subjects to respond to a red light with a right-hand button, and respond to a green light with a left-hand button without regard for where the stimulus was presented. Responses to the red stimulus were faster when it was presented to the right eye than when it was presented to the left eye. Likewise, responses were faster for a green stimulus when it was presented to the left eye. Thus, the task-irrelevant spatial position of the stimulus influenced responding to the task-relevant color of the stimulus (see also Hedge & Marsh, 1975; Proctor & Lu, 1994; Umiltà & Nicoletti, 1985). As an example of cross-modal stimulus interaction, Simon and Craft (1970) presented lights to the left or right of fixation, accompanied by high or low-pitched tones presented to the left or right ears. The ear of presentation for the tone was irrelevant to the task, yet responses were faster when the ear of presentation matched the stimulus presentation side.

Although nearly all of the work on the Simon effect with auditory stimuli has used the left-right spatial distinction, Simon et al. (1976) examined the effects of vertical spatial location (i.e., the speaker from which the sound was presented, which was irrelevant to the task in this case) on responses to the pitch of a stimulus. As is the case when left and right spatial locations affect performance even though nominally irrelevant to the task, Simon et al. found a strong effect of the irrelevant spatial information on reactions to pitch (when high and low pitches were compatibly assigned to high and low responses). When the high pitch stimulus (i.e., high in terms of pitch, not in terms of vertical position) was paired with an upward toggle response, and the low pitched stimulus with a downward toggle response (i.e., in a compatible assignment of the relevant stimulus dimension to the responses), responses were significantly faster when the high pitches emanated from the upper speaker, rather than from the lower speaker. In other words, when the irrelevant spatial dimension of the stimulus (i.e., upper vs. lower speaker) was spatially compatible with the correct response, responses were faster than when the spatial location of the sound and the response did not correspond.

Dynamic stimuli and compatibility effects. Some of the studies that looked at congruency effects with dynamic visual stimuli also examined S-R compatibility effects, in particular the effect of the compatibility of task-irrelevant spatial information (e.g., Ehrenstein, 1994). Compatibility effects with dynamic auditory stimuli have yet to be studied. However, if auditory stimuli that change in pitch can be considered dynamic in that they move up or down in the so-called “pitch space”, and if the responses to such stimuli are arranged vertically, then S-R compatibility effects should be observed. A Simon effect for such dynamic auditory stimuli might also be expected, if the position and movement of a sound in the pitch space affect responses to other attributes of the stimulus even when they are irrelevant to a selective listening task. It should be noted that sounds can be made dynamic in several other ways, including moving them in space around the listener (via phase shifts for simple left-right motion, or via three-dimensional convolution; e.g., Wenzel, Arruda, Kistler, & Wightman, 1993). Such dynamic auditory stimuli may also result in S-R compatibility effects. However, since sounds that change in pitch are important for the auditory display of information, the present study focused on stimuli that are dynamic in the pitch space.

EXPERIMENT 1

If it is possible to attend selectively to the onset pitch of a stimulus while ignoring the direction of pitch change, then the time it takes to judge whether a tone is high or low in pitch, and the accuracy of this judgment, should not depend on pitch change. That is, whether a high pitch becomes lower or higher in pitch and a low pitch becomes lower or higher in pitch should not affect performance. However, if the pitch-change information intrudes on the pitch decision, the speed and accuracy of responses to high pitches that become higher and to low pitches that become lower should be better than for responses to high pitches that become lower and low pitches that become higher. This is because the high pitches that become higher and the low pitches that become lower provide congruent information to the listener, in that the pitch change makes the stimulus “more” of what it already is, namely “high” or “low” in pitch. The high pitches that become lower and the low pitches that become higher provide conflicting, or incongruent information to the listener, which should result in performance deficits for responses to those stimuli. Similar arguments could be made for the effects of onset pitch on judgments of pitch change. For example, a tone that becomes higher in pitch, and that starts at an already high pitch, is never “low”, so it provides congruent information to the listener. A tone that is becoming higher in pitch, but is initially “low” provides incongruent information to the listener, and this may necessitate more or different processing of the stimulus. Responses to the congruent stimuli will likely be faster than responses to the incongruent stimuli.

To investigate interactions between the dimensions of pitch and pitch change, sounds that started at a given pitch, and then became higher in pitch (i.e., changed to a higher frequency), or became lower in pitch (i.e., changed to a lower frequency) were presented. Subjects were instructed to listen to the sounds, attending selectively either to the pitch or to the direction of pitch change, and then make a speeded classification according to whether the pitch was high or low, or becoming higher or lower, respectively.

The experiment used a set of 12 stimuli, each of which became higher or became lower in pitch from one of several starting pitches (see Figure 1). The use of a large stimulus set helped avoid any problems that might otherwise result if there were peculiarities in responding to specific pitches or pitch changes. On the basis of pilot testing, it seemed necessary to use a relatively large set of stimuli to prevent subjects from learning to associate a particular response with a given stimulus, and to encourage participants to listen analytically to either the onset pitch or direction of pitch change.

Method

Participants. Twenty-eight Rice University undergraduates each participated in a one-hour experiment for partial credit in a psychology course. All subjects reported normal hearing, and none had participated in the pilot studies. Subjects were assigned randomly to conditions, with the constraint that there were equal numbers of subjects in each condition.

Apparatus. Subjects were tested individually in a small testing room, at a table with an IBM-compatible 486-DX 33-MHz computer, 14-in. color VGA monitor and standard 101-key keyboard. A program written in MEL (Micro Experimental Laboratory; Schneider, 1988; 1995) controlled stimulus presentation and data collection. Auditory stimuli were presented by the computer's internal speaker, centrally located with respect to the subject. Responses were made using the “6” and “9” keys on the numeric keypad with their right index and middle fingers, respectively. Due to the tilt of the keyboard, the “9” key was slightly above the “6” key (and slightly further from the subject), for a quasi-vertical arrangement of responses.

Stimuli. The stimuli were brief pitch glides composed of a series of short pitches (see Figure 1 and Appendix A for the initial and final frequencies of the stimuli). The duration of each sound was 250 ms, with 10 intermediate steps creating an apparently continuous change in pitch. The changes in the stimulus pitch were made equal in terms of log frequency in order to equate the change in perceived pitch for all stimuli.

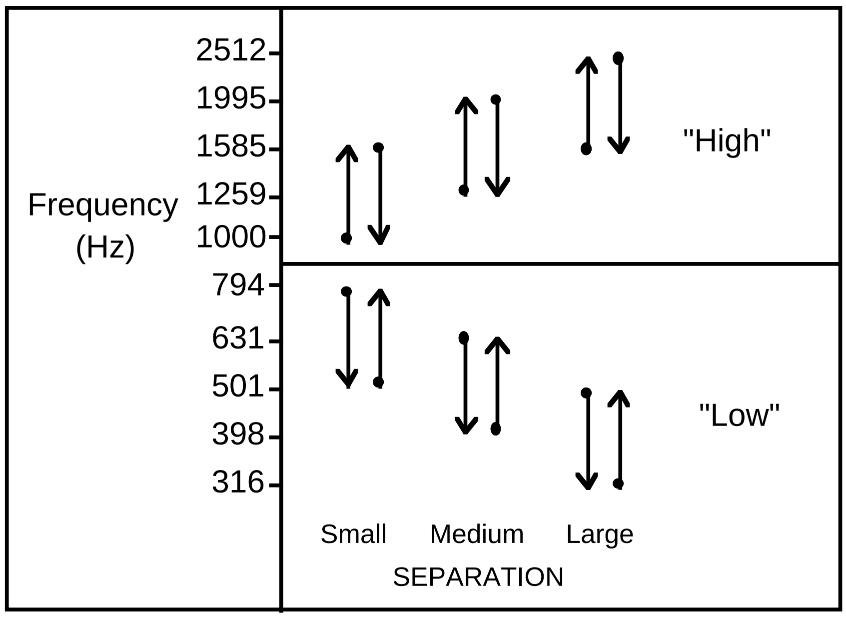

FIGURE 1. Schematic representation of the 12 auditory stimuli. The circle represents the starting pitch, and the arrow indicates the direction of pitch change, with the final pitch at the tip of the arrow. Note that the vertical axis is log frequency; thus, the equal arrow lengths reflect equal changes in perceived pitch for each stimulus. The initial and final frequencies are summarized in Appendix A. The horizontal line in the figure represents the relative "middle" of this pitch space: Stimuli that started above this frequency were considered relatively "high" in pitch and the others were considered relatively "low" in pitch. The stimuli are also labeled in terms of their separation, or relative distance from the middle of the stimulus set.

Stimuli for which the sound started high and became higher or started low and became lower in pitch were considered "congruent", since their onset position and direction of pitch change corresponded (the left stimulus in each group of two stimuli in

Figure 1). The stimuli whose starting position and direction of pitch change were opposite were called "incongruent" (the right stimulus of each pair in Figure 1).

The stimuli can also be described in terms of their difference from the average pitch, with each stimulus being considered to have a small, medium or large "separation". The four sounds that were closest to the middle of the set had "small" separation (the four left-most stimuli in Figure 1). The four sounds that were highest and lowest relative to the middle of the pitch range were considered to have "large" separation, and the remaining four had "medium" separation. Note that separation was defined not in terms of onset pitch, but rather in terms of the average pitch for each stimulus.

Procedure. Subjects were told that they would hear sounds that would start either high in pitch or low in pitch, and which would become higher or lower in pitch. In one condition the task was to respond to whether the stimulus started high or started low, irrespective of the direction of pitch change. In the other condition, the task was to respond to whether the pitch became higher or lower, ignoring the onset pitch. In all cases, responses were keypresses of the "6" and "9" keys of the numeric keypad with the index and middle fingers of the right hand, respectively.

During the instruction phase, the subject heard each of the 12 stimulus sounds once. An accompanying message on the computer screen indicated, "These are the three tones that start high, and become higher in pitch," when the three high and congruent stimuli were played; the same method was used to present the remaining stimuli. Following presentation of the stimuli, the subject was assigned to one of two S-R assignments. Half of the subjects were instructed to respond using what was intended to be a spatially compatible S-R assignment, pressing the upper key (the "9" key) when the stimulus started high (or moved up in pitch), and pressing the lower key (the "6" key) when the stimulus started low (or moved lower). The other half of the subjects were instructed to respond using what was intended to be a spatially incompatible S-R assignment (e.g., pressing the lower key when the stimulus started high in pitch, and pressing the upper key when the stimulus started low in pitch).

There were two sessions to the experiment. In each session subjects completed a block of 60 practice trials, then performed 2 blocks of 60 experimental trials, for a total of 180 trials. There were five repetitions of each of the twelve stimuli randomly presented within each block. Accuracy feedback was given on each trial, and overall accuracy was presented at the end of each block. Half of the subjects responded to the onset position for the first session (ignoring the direction of movement), and then responded to the direction of motion (ignoring onset position) in the second session. The other subjects responded first to direction, then responded to position in the second session.

At the conclusion of the second session, each subject was given a brief explanation of the purpose of the study and was dismissed from the experiment.

Results

Practice trials were excluded from the analysis. In addition, responses faster than 100 ms or slower than 2000 ms (less than 1% of responses) were excluded. Mean correct RTs and mean accuracy were subjected to an analysis of variance (ANOVA) with order (respond to position then to direction vs. respond to direction then to position) and assignment (compatible S-R assignment vs. incompatible assignment) as between-subjects factors, and cue dimension (position vs. direction), congruency (congruent vs. incongruent), separation (small, medium, or large stimulus separation) and block (Block 1 vs. 2) as within-subjects factors. An alpha level of .05 was used for all statistical tests.

RT results are plotted in Figure 2 as a function of cue dimension, separation and congruency.

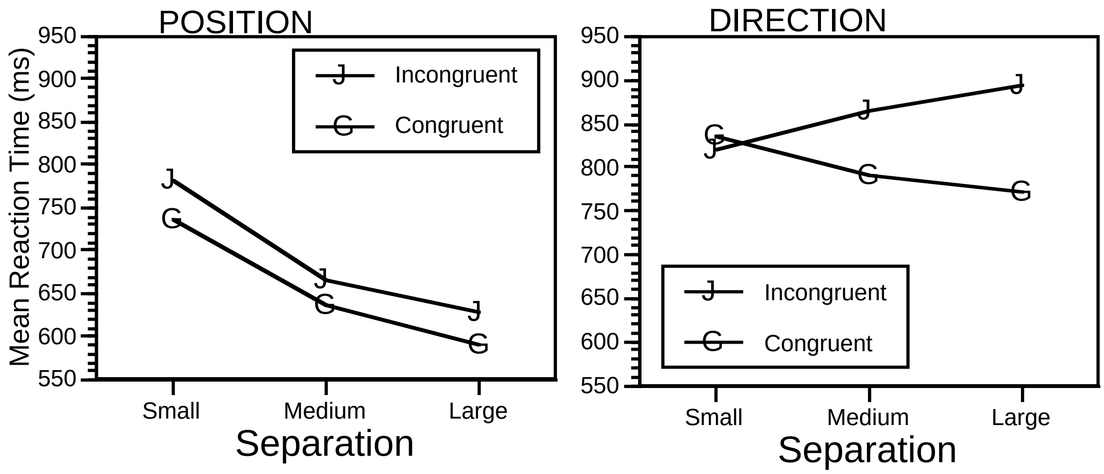

FIGURE 2. Mean RT results of Experiment 1 as a function of cue dimension, congruency and separation.

The main effect of cue dimension was significant, reflecting that overall responses were faster [676 vs. 832 ms; $F(1, 24) = 13.00$, $p < .0014$, $MSE = 314{,}462$] and more accurate [94 vs. 87%; $F(1, 24) = 7.20$, $p < .0130$, $MSE = 0.0576$] for position judgments than for direction judgments.

The main effect of congruency was significant for RT and for accuracy. Responding was faster [729 vs. 782 ms; $F(1, 24) = 11.80$, $p < .0022$, $MSE = 37{,}457$] and more accurate [94 vs. 88%; $F(1, 24) = 10.77$, $p < .0032$, $MSE = 0.0268$] for congruent stimuli than for incongruent stimuli.

The Cue Dimension x Congruency interaction did not reach significance for RT, $F(1, 24) = 2.70$, $p < .11$, $MSE = 16{,}051$, but it was significant for accuracy, $F(1, 24) = 8.46$, $p < .0077$, $MSE = 0.0103$. When attending to position, responses to congruent stimuli were more accurate than responses to incongruent stimuli (96.0 vs. 93.4%, respectively). When attending to direction, responses to congruent stimuli were also more accurate than to incongruent stimuli, but the congruency effect was larger for the direction judgments (92.7 vs. 82.9% for congruent and incongruent, respectively).

As separation increased, responses became significantly faster [mean RT = 793 ms at the smallest separation, 744 ms at the medium separation and 731 ms at the largest separation; $F(2, 48) = 25.40$, $p < .0001$, $MSE = 9{,}489$]. Accuracy also tended to be higher at the greater separations [from 89 to 93 to 91%; $F(2, 48) = 13.61$, $p > .001$, $MSE = 0.0051$).

The Cue Dimension x Separation interaction was significant, $F(2, 48) = 42.03$, $p < .0001$, $MSE = 7{,}780$. The pattern of faster responses for a greater stimulus separation was stronger for position judgments (mean RT = 760, 651 and 609 ms, for small, medium and large stimulus separation, respectively), than for direction judgments (mean RT = 827, 831 and 839 ms, for small, medium and large separations, respectively). The Congruency x Separation interaction was also significant, $F(2, 48) = 8.45$, $p < .0007$, $MSE = 8{,}185$. As separation increased, RTs decreased for both congruent and incongruent stimuli, however the difference in RT between the smallest and largest separation was only 25 ms for incongruent stimuli, whereas it was 103 ms for congruent stimuli. Finally, the Cue Dimension x Congruency x Separation interaction was significant, $F(2, 48) = 13.41$, $p < .0001$, $MSE = 6{,}778$. As shown in Figure 2, when attending to position (left side of Figure 2), responses to both congruent and incongruent stimuli were faster with an increased stimulus separation (congruent: 738, 637 and 591 ms; incongruent: 783, 665 and 627 ms for small, medium and large separations, respectively). However, when attending to direction, increased stimulus separation led to faster responding only for congruent stimuli (right side of Figure 2, open squares; 836, 792, 772 ms), whereas for incongruent stimuli, increased separation led to slower responding (filled circles; 820, 867 and 895 ms for small, medium and large separation, respectively).

The main effect of assignment was not significant for RTs, $F(1, 24) < 1$, nor did assignment appear in any significant interaction (see Appendix B for the complete ANOVA tables). In terms of accuracy, the main effect of assignment was also not significant, $F(1, 24) < 1$, however assignment did appear in some significant higher-order interactions, as seen in Appendix B.

There was no main effect of order, $F(1, 24) = 2.14$, $p > .16$, *MSE* = 830,413, nor were there any significant two-way interactions involving Order. The three-way Order x Cue Dimension x Separation interaction was significant for RT, $F(2, 48) = 7.05$, $p < .0021$, *MSE* = 7,780. Regardless of the order of conditions, position responses were faster for larger separations (position then direction order: mean RT = 659, 571 and 547 ms for small, medium and large separation, respectively; direction then position order: mean RT = 862, 731 and 669 ms). For direction responses, however, responding first to position then to direction (Order 1) resulted in little change to direction responses with increased separation (mean RT = 820, 795 and 818 ms for small, medium and large separation). Responding to direction first, then to position (Order 2) resulted in an increase in RTs with greater separation (mean RT = 835, 867, 861 ms for small, medium and large separation).

The significant main effect of block on accuracy showed that performance improved with practice, as mean accuracy increased from 90% in Block 1 to 92% in Block 2, $F(1, 24) = 7.19$, $p < .0131$, *MSE* = 0.0028, while RT remained unchanged [756 vs. 758 ms, $F(1, 24) < 1$]. This reflects the typical improvement in performance that results from practice on a speeded-reaction task.

Discussion

As predicted, the dimensions of pitch and pitch change interacted, so that responses were almost always faster when the direction of pitch change matched the onset pitch position (i.e., for congruent stimuli). This parallels the results of studies using static auditory stimuli, as well as both static and dynamic visual stimuli. It is important to note that dynamic auditory stimuli (i.e., changing pitches) seem to behave in some ways similar to dynamic visual stimuli. That is, the dimension of position influences the perception of, and responding to, direction, and vice versa. This makes it clear that both pitch and pitch change need to be considered when designing auditory stimuli and auditory displays, but it also provides a visual analogy to help designers remember and understand the interaction of two stimulus dimensions.

Overall, in this experiment responding to pitch position was faster than responding to direction of pitch change. This is likely due, at least in part, to the fact that responding to direction required waiting until the pitch changed (i.e., a minimum of 25 ms, the amount of time that the stimulus remained at the onset pitch). However, that does not explain the responses to direction being more than 150 ms (i.e., more than half the duration of the stimulus) slower on average. It is possible that pitch is processed in some way differently from direction of pitch change, which could lead to faster responses. Subjects may also have more pre-experimental practice with pitch judgments than with pitch-change judgments, resulting in what amounts to a long-term practice effect. Alternatively, the dimension of pitch may have been simply more effective at making the stimuli more or less discriminable. At this point it is not possible to know conclusively why pitch responses were faster, but the use of twelve stimuli was intended to help balance the stimulus set so that any discriminability issues would be minor in comparison to the effects of practice or differential processing speeds.

It is interesting to note how cue dimension, separation and congruency interacted (see Figure 2). Position judgments were faster for congruent stimuli than for incongruent stimuli, but for both congruent and incongruent stimuli the greater the separation, the faster the responses to position (left panel of Figure 2). It makes sense that more separated pitches would result in faster responses when pitch is the cue dimension, since separation can also be considered a measure of stimulus discriminability for pitch. Within the stimulus set, it should be easiest to respond to stimuli that are more discriminable. The slowdown due to incongruent direction information is fairly constant with increased separation, suggesting that direction information has a uniform effect on position judgments for all of the stimuli. This tends to confirm that a change in perceived pitch (which was equal at each separation), and not in absolute frequency (which varied from 185 to 927 Hz), is processed when judging direction.

When attending to direction, a different pattern of results was obtained. Congruent stimuli were, on the whole, still faster than incongruent stimuli, but there was little gain in performance with increased separation (right panel of Figure 2, open squares). That is, direction judgments seemed unaided by greater separation when the pitch and the direction matched. When the pitch was incongruent with the direction of pitch change, however, greater separation meant much slower responses to direction. Hence, it appears that the further the pitches were from the middle of the pitch space, the more salient pitch became, and the greater its interference with direction judgments. This was especially true for the largest level of separation. When separation was small, it was apparently harder to discriminate the different pitches, making pitch less salient. In this case it was apparently easier to ignore the irrelevant position information, as indicated by better performance on the direction judgment.

Based on these results, it seems reasonable to conclude that if pitch is the dimension of a dynamic auditory message to which an operator must attend, there will always be some intrusion of the direction information. Selective attention is not perfect. However, a greater separation in the onset of pitches will mean better performance on the task, with no increased interference from direction information as a result. If pitch change is the important dimension, then in terms of performance on a selective listening task there is little to be gained with increased pitch separation in the case of congruent stimuli, and much to be lost in the case of incongruent stimuli. Hence, to reduce the deleterious effects of the irrelevant pitch information, an auditory display designer can restrict the range over which stimulus onsets may vary for a given task.

The lack of any assignment effect in the present experiment is surprising. If pitch really were treated by listeners as having a spatial aspect (e.g., Mudd, 1963), then there should have been spatial compatibility effects resulting from the different assignments of stimuli to responses. If there really is no effect of assigning upper keypresses to high-pitched rather than low-pitched sounds, and vice-versa for lower keypresses, that would suggest that pitch is not really spatial, or at least that the pitch space is not comparable to the response space in this case.

There may, however, be other reasons for the lack of an assignment effect. If, for example, the response set were not spatial, or even if the response set were arranged in a spatial, but non-vertical way, then a vertically oriented pitch space might not interact with the responses to cause spatial compatibility effects. That is, if the responses were left-right, pitch could be coded as up-down, such that a detectable compatibility effect might not be present. Recent evidence (Lippa, 1996) indicates that the arrangement of responses must be assessed relative to the hand of the subject, and not relative to the subject's body or the rest of the apparatus. Lippa found that for visual stimuli certain types of spatial S-R compatibility effects were found only if the relevant stimulus dimension (e.g., vertical position of lights) was aligned parallel to the response set (e.g., two vertically arranged buttons), with the alignment of the responses being determined relative to the hand, not relative to the rest of the body. Although the response keys in the present experiment (the “6” and “9” keys on the numeric keypad) were chosen so that the “9” key would be higher than the “6” key, the subjects may not have treated them as being in a truly vertical arrangement. The bent arm position that was required to put the right index finger on the “6” key and the second finger on the “9” key of the numeric keypad would result in a left-right arrangement of the keys, relative to the hand. In addition, while the “9” key is physically located higher than the “6” key, it is only slightly so, and in any case, it is not really “higher” relative to the whole hand. Thus, considering Lippa's results, a more vertical response set might correspond more closely to the pitch space, and result in spatial compatibility effects. Such a finding would provide evidence that pitch really is treated by listeners in a spatial way.

In addition to making the vertical alignment of the response set more salient, it may be necessary to increase the salience or "separation" of the responses. After all, the separation of the stimuli in the pitch space affected responding, so greater or lesser separation of the responses may have a similar effect. Experiment 2 thus used a modified response set to address these concerns.

EXPERIMENT 2

Method

Experiment 2 was identical to Experiment 1, except for the following: First, the response apparatus was changed to create a truly vertical response set, and two different sets of response buttons, differing only in their separation relative to each other, were used. Second, due to suspected differential carry-over effects in Experiment 1, cue dimension was changed to a between-subjects variable.

Participants. Sixty-four new subjects from the same subject pool as in Experiment 1 participated in this experiment. None of the subjects had participated in any of the previous pilot studies nor in Experiment 1.

Apparatus. The computer apparatus that controlled the experiment and presented the sound stimuli was identical to that used in Experiment 1, except that subjects now responded by pressing the buttons of a five-button PST Serial Response Box (a response device produced by Psychological Software Tools, specifically for use with the MEL experiment-control software system), which was supported on a wooden stand as illustrated in Figure 3. The response buttons were arranged in a single vertically oriented row, although the whole response box was inclined away from the subject at a 10° angle to allow the subject to press the buttons with the fleshy part of the fingertip, rather than the tip of the fingernail. For the purposes of explanation, the buttons will be referred to here in numerical order, starting from the bottom. Thus, the lowest button is "Button 1" and the top button is “Button 5” (they were not so labeled for the subjects). Subjects rested their right wrist on a 5-cm thick piece of foam placed on the table between the subject and the response box. This maintained a comfortable arm and hand position, while allowing for unimpeded movement to any of the response buttons. All responses were performed with the right index finger. There were two types of responses: the “near” responses, which involved moving from the “home” button to either Button 2 or Button 4 (see Figure 3), and the “far” responses, which involved moving from the “home” button to either Button 1 or Button 5.

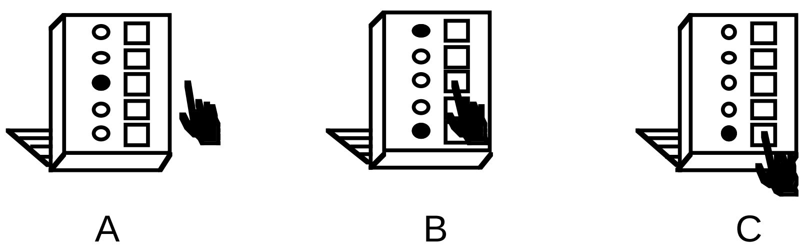

FIGURE 3. Schematic diagram of the apparatus used in Experiment 2. Panel A shows the start of a trial. Panel B shows the subject pressing the middle “home” button, while waiting for the stimulus sound. Panel C shows the response apparatus just after a correct “far” response has been made.

Stimuli. The stimuli were identical to those used in Experiment 1.

Procedure. The trial procedure differed from Experiment 1 only as follows: At the start of each trial, the light beside the middle button (Button 3) of the response box came on (see Panel A of Figure 3). The subject began the trial by pressing down and holding this “home” button, and waiting for the stimulus sound. When the home button was pressed and held, the middle light was turned off and the lights were turned on beside Buttons 2 and 4 (in the near-response condition), or beside Buttons 1 and 5 (in the far-response condition), as a reminder of the valid responses for that trial (Panel B of Figure 3). The subject waited for the stimulus sound, then, as quickly as possible, moved the index finger off the home button and pressed one of the valid response buttons. If the subject pressed the correct button, the light beside it stayed on (recall that it was already on as a reminder to the subject), the other lights were turned off and the message, "Correct response" appeared on the computer screen (see Panel C of Figure 3). If the subject pressed an incorrect button (or made no response within 3 s), all the response box lights came on and "Wrong response!" appeared on the computer screen. Finally, if the subject released the home button before the stimulus started, the message, "You moved too soon!" appeared on the computer screen.

The block structure was the same as in Experiment 1, with three blocks of 60 trials in each session of the experiment. Instead of responding to a different cue dimension in each session, as was the case in Experiment 1, the subjects now responded to the same cue dimension, either position or direction, for the entire experiment. In one session subjects now used the "near" buttons to respond and in the other session they used the "far" buttons. This order of response types was counterbalanced across subjects.

As in Experiment 1, half of the subjects responded throughout with a compatible response assignment, whereas the other half of the subjects responded throughout with an incompatible assignment.

Results

The practice trials and trials on which responses were less than 100 ms or greater than 3000 ms (less than 0.5% of trials) were excluded from the analysis.

Mean correct RTs and mean accuracy were subjected to separate ANOVAs, with cue dimension (position vs. direction), assignment (compatible vs. incompatible) and order (near response condition, then far response condition vs. far then near) as between-subjects factors. Response type (near vs. far), congruency (congruent vs. incongruent), separation (small, medium or large) and block (Block 1 or 2) were within-subjects factors. Total RT (the time from the onset of the sound until the response button-press) and accuracy were the primary dependent measures, as before. In addition, the time required to release the home button ("lift time"), and the time required to move to the response button ("movement time") were analyzed separately (see Appendix C for the ANOVA tables). Lift and movement times will be discussed only where the results of the analyses differ from the total RT results.

The analysis of the whole experiment showed significant effects of the order in which the response types were used. For that reason, the data from the first session for each subject were also analyzed separately (such that only the data from the first response type that each subject used were included). The results of the Session 1 analysis are presented following the report of the complete experiment.

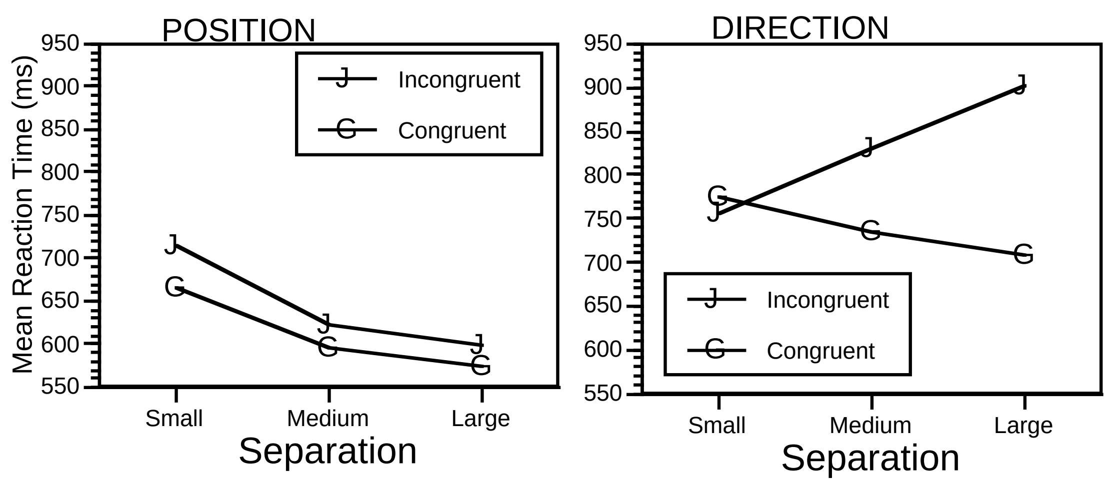

FIGURE 4. Mean RT results of Experiment 2 as a function of cue dimension, congruency and separation.

ANOVA Results for the Complete Experiment. Mean correct RTs, as a function of cue dimension, separation and congruency, are presented in Figure 4. The main effect of cue dimension was significant, reflecting that overall responses were faster for position judgments than for direction judgments [628 vs. 784 ms, respectively; $F(1, 56) = 12.14$, $p < .0010$, $MSE = 770{,}198$]. The main effect of cue dimension was not significant for accuracy, $F(1, 56) = 1.18$, $p < .2818$, $MSE = 0.086$.

The significant main effect of congruency for both RT, $F(1, 56) = 47.48$, $p < .0001$, $MSE = 30{,}777$, and accuracy, $F(1, 56) = 16.85$, $p < .0001$, $MSE = 0.047$, reflects the fact that responses to congruent stimuli were faster (676 vs. 737 ms) and more accurate (96.4 vs. 91.1%) than responses to incongruent stimuli.

The Cue Dimension x Congruency interaction also was significant for RT, $F(1, 56) = 10.25$, $p < .0023$, $MSE = 30{,}777$, but not for accuracy, $F(1, 56) = 3.23$, $p < .0777$, $MSE = 0.047$. When attending to position, responses to congruent stimuli were 33 ms faster than responses to incongruent stimuli (612 vs. 645 ms). When attending to direction, however, the difference between responses to congruent and incongruent stimuli was 91 ms (739 vs. 830 ms for congruent and incongruent, respectively).

As separation increased, RT decreased significantly [mean RT = 728 ms at the smallest separation, 696 at the medium separation and 695 ms at the largest separation, $F(2, 112) = 16.69$, $p < .0001$, $MSE = 111{,}141$]. Accuracy also tended to be higher at the greater separations [accuracy = 91.9, 95.7 and 94.8% for small, medium and large separations, respectively; $F(2, 112) = 24.55$, $p < .0001$, $MSE = 0.008$].

The Cue Dimension x Separation interaction was significant for RT, $F(2, 112) = 62.59$, $p < .0001$, $MSE = 11{,}141$. When position was the relevant cue dimension, RTs decreased with increased separation (691, 610 and 585 ms for small, medium and large separations, respectively). However, when attending to direction, RTs tended to be slower with increased separation (766, 781 and 806 ms for small, medium and large separations, respectively). The Cue Dimension x Separation interaction was also significant for accuracy, $F(2, 112) = 82.39$, $p < .0001$, $MSE = 0.008$. When position was the relevant cue dimension, accuracy increased with increasing separation (accuracy =

88.6, 97.9 and 98.3% for small, medium and large separations, respectively). When direction was the relevant cue dimension, however, accuracy decreased with greater separation (accuracy = 95.2, 93.5 and 91.3% for small, medium and large separations, respectively), thus showing the same pattern of performance as the RT results.

The Congruency x Separation interaction was significant for both RT, $F(2, 112) = 19.08$, $p < .0001$, *MSE* = 14,754, and accuracy, $F(2, 112) = 5.71$, $p < .0044$, *MSE* = 0.005. For congruent stimuli, RTs decreased and accuracy increased with increasing separation (mean RT = 721, 665 and 641 ms; accuracy = 93.1, 97.5 and 98.6% for small, medium and large separations, respectively). However, for incongruent stimuli, RTs tended to increase from 736 ms at the smallest separation to 750 ms at the largest separation, while accuracy tended to increase slightly from 90.7% at the smallest separation to 91.0% at the largest separation.

Finally, the Cue Dimension x Congruency x Separation interaction was significant for RT, $F(2, 112) = 30.54$, $p < .0001$, *MSE* = 14,754, and for accuracy, $F(2, 112) = 20.06$, $p < .0001$, *MSE* = 0.016. As seen in Figure 4, for subjects who attended to position throughout the experiment (left side of Figure 4), responses to both congruent and incongruent stimuli were faster with increased stimulus separation (congruent: mean RT = 666, 597 and 573 ms; incongruent: mean RT = 715, 622, 598 ms for small, medium and large separations, respectively). Accuracy for these responses followed the same pattern, in that responses to both congruent and incongruent stimuli were more accurate with increased separation (congruent: accuracy = 91.4, 98.6 and 98.6%; incongruent: accuracy = 85.9, 97.1 and 98.0% for small, medium and large separations, respectively). However, when direction was the relevant dimension (right side of Figure 4), RTs to congruent stimuli decreased with increased separation (mean RT = 775, 734 and 709 ms), whereas responses to incongruent stimuli showed the opposite pattern, namely a pronounced slowing with increased stimulus separation (mean RT = 757, 830 and 902 ms for small, medium and large separations, respectively). The accuracy results again followed the same pattern as the RT results, as direction responses to congruent stimuli became more accurate with greater separation (accuracy = 94.8, 96.4 and 98.5% for small, medium and large separation) whereas direction responses to incongruent stimuli became less accurate with increased separation (95.5, 90.5 and 84.1% for small, medium and large separations, respectively). The pattern of results for this three-way Cue Dimension x Congruency x Separation interaction is identical to the pattern found in Experiment 1.

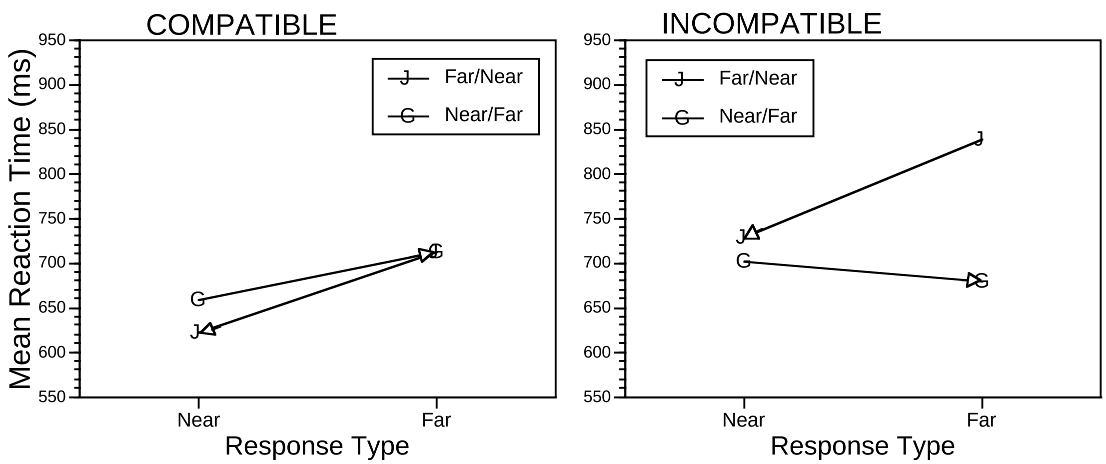

FIGURE 5. Mean RT results in Experiment 2 as a function of assignment, response type and order.

The main effect of assignment was not significant for RT, $F(1, 56) = 1.85$, $p < .18$, $MSE = 770{,}198$, nor for accuracy, $F(1, 56) = 1.01$, $p < .32$, $MSE = 0.086$, however, assignment figured in a three-way interaction, as discussed below.

The significant main effect of response type for RT reflects that overall responding to the near buttons was significantly faster than responding to the far buttons [677 vs. 736; $F(1, 56) = 43.06$, $p < .0001$, $MSE = 30{,}480$]. The main effect of response type was not significant for accuracy, $F(1, 56) = 3.62$, $p < .0623$, $MSE = 0.015$. The

Assignment x Response Type interaction was not significant for RT, $F(1, 56) = 2.78$, $p < .10$, $MSE = 30{,}480$, nor for accuracy, $F(1, 56) < 1$.

The main effect of order was not significant for RT, $F(1, 56) < 1$, nor for accuracy, $F(1, 56) = 1.65$, $p < .20$, $MSE = 0.086$. The Assignment x Order interaction was not significant for RT, $F(1, 56) = 1.56$, $p < .22$, $MSE = 770{,}198$, nor for accuracy, $F(1, 56) = 1.81$, $p < .18$, $MSE = 0.086$. There was, however, a significant Response Type x Order interaction for RT, $F(1, 56) = 22.66$, $p < .0001$, $MSE = 30{,}480$, and for accuracy, $F(1, 56) = 13.48$, $p < .0005$, $MSE = 0.015$, but this effect was qualified by several significant three-way interactions. The Assignment x Response Type x Order interaction was significant for RT, $F(1, 56) = 7.03$, $p < .0104$, $MSE = 30{,}480$ (see Figure 5), but not significant for accuracy, $F(1, 56) = 2.19$, $p < .14$, $MSE = 0.015$. For the compatible assignment (left side of Figure 5), both orders resulted in near responses being faster than far responses (near-then-far order: near mean RT = 658, far mean RT = 713 ms; far-then-near order: near mean RT = 621, far mean RT = 712 ms), which is most likely due to the greater distance traveled by the finger to make the far responses. For subjects who used an incompatible S-R assignment (right side of Figure 5), the far-then-near order also resulted in the near responses being faster than the far responses (upper arrow: near mean RT = 729, far mean RT = 838 ms). However, the near-then-far order with an incompatible S-R assignment resulted in the opposite pattern of results, namely the near responses being slower than the far responses (lower arrow: near mean RT = 702, far mean RT = 679 ms).

There was some evidence of a compatibility effect when making far responses as the first response type (the right-most filled circle in each panel of Figure 5), as compatible responses were numerically faster than incompatible responses (mean RT = 712 vs. 838 ms for compatible and incompatible responses, respectively), however this difference did not reach significance, $t(1, 30) = 1.63$, $p > .10$].

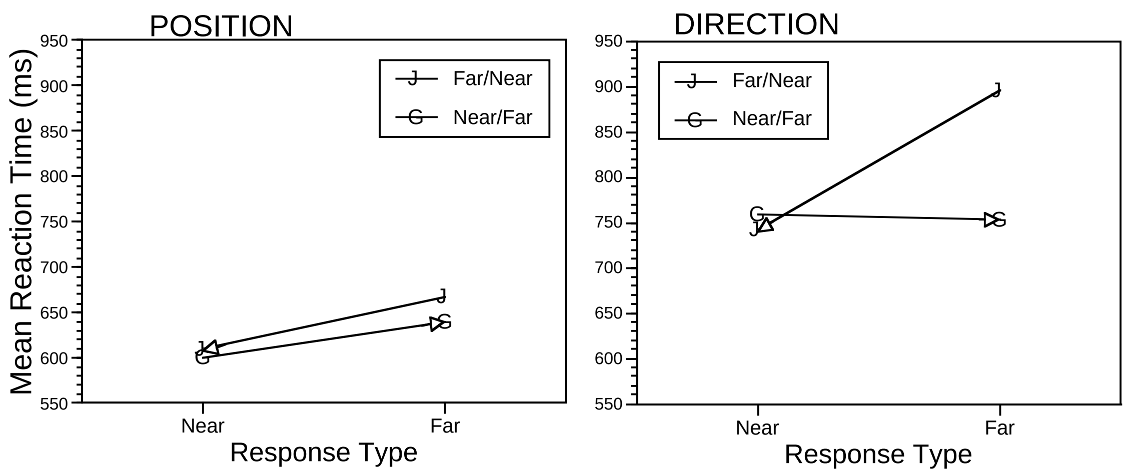

FIGURE 6. Mean RT results in Experiment 2 as a function of cue dimension, response type and order.

The Cue Dimension x Response Type x Order interaction was significant for RT, $F(1, 56) = 13.50$, $p < .0005$, $MSE = 30{,}480$, but not for accuracy, $F(1, 56) = 3.64$, $p < .0617$, $MSE = 0.015$. The pattern of RTs (shown in Figure 6) was very similar to the pattern just described for the Assignment x Response Type x Order interaction. For the subjects who attended to position (left side of Figure 6), near responses were faster in both the near-then-far order (near mean RT = 601, far mean RT = 639 ms) and the far-then-near order (near mean RT = 609, far mean RT = 666 ms). For subjects who attended to direction of pitch change (right side of Figure 6), the far-then-near order resulted in faster responding to the near buttons (near mean RT = 741, far mean RT = 895 ms), but in the near-then-far order the far responses were slightly faster than the near responses (near mean RT = 759, far mean RT = 753 ms).

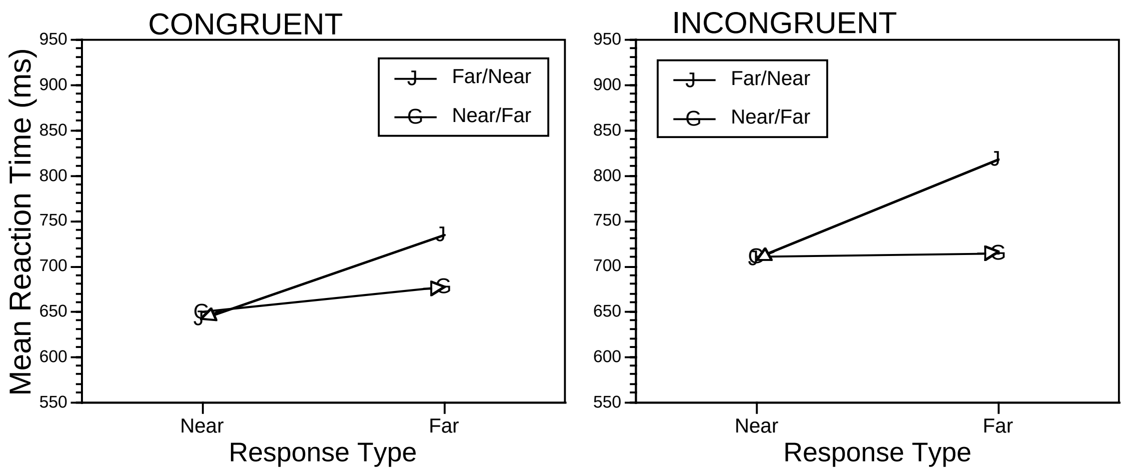

FIGURE 7. Mean RT results in Experiment 2 as a function of congruency, response type and order.

The Congruency x Response Type x Order interaction was also significant for both RT, *F*(1, 56) = 4.85, *p* < .0318, *MSE* = 7,959, and accuracy, *F*(1, 56) = 11.98, *p* < .0010, *MSE* = 0.006, and the pattern of RT results (shown in Figure 7) was very similar to that of the two interactions just described. For responses to congruent stimuli (left side of Figure 7), both orders resulted in the near responses being faster than the far responses (near-then-far order: near mean RT = 650, far mean RT = 677 ms; far-then-near order: near mean RT = 642, far mean RT = 734 ms). For responses to incongruent stimuli (right side of Figure 7), the far-then-near order resulted in much faster responding to the near buttons (near mean RT = 708, far mean RT = 817 ms), and in the near-then-far order the near responses were also slightly faster than the far responses (near mean RT = 710, far mean RT = 715 ms). In terms of accuracy, for responses to congruent stimuli, both orders resulted in the near responses being less accurate than the far responses (near-then-far order: near accuracy = 96.1, far accuracy = 98.2%; far-then-near order: near accuracy = 95.6, far accuracy = 95.7%). Thus, there seems to be a speed-accuracy tradeoff for these responses. For responses to incongruent stimuli, in the far-then-near order near responses were more accurate than far responses (near accuracy = 91.9, far accuracy = 89.5%), whereas in the near-then-far order near responses were less accurate than far responses (near accuracy = 90.6, far accuracy = 95.5%). This pattern of results for accuracy again suggests a speed-accuracy tradeoff in performance.

The main effect of block on total RTs was significant, as RTs decreased from Block 1 to Block 2 [717 vs. 696 ms, $F(1, 24) = 5.77$, $p < .0197$, $MSE = 28{,}277$] and overall accuracy increased [93.6 to 94.7%, $F(1, 24) = 7.08$, $p < .0102$, $MSE = 0.0061$]. The main effect of block was not significant for movement time, $F < 1$, but it was significant for lift time, suggesting that performance did not improve due to faster movements, but rather due to faster planning or faster initiation of the action [359 vs. 344 ms for lift time, in Blocks 2 and 3, respectively; $F(1, 56) = 6.03$, $p < .0172$, $MSE = 15{,}799$].

ANOVA Results for the First Session. Since there were effects of the order in which the near and far responses were used, it may have been the case that compatibility effects were present in the initial session of the experiment, but the change of response mode obscured the effect. Therefore, the data from the first session for each subject (thus making response type a between-subjects factor) were analyzed in a separate ANOVA. Other than the omission of order as a factor and the treatment of response type as a between-subjects factor, the analysis was identical to the ANOVAs performed on the complete experiment.

The overall pattern of results for the first session was very similar to the pattern of results for the complete experiment (see Appendix D for the ANOVA tables). In the following, accuracy results will only be reported where they differ from the RT results. The main effects and interactions of cue dimension, congruency and separation followed the identical pattern as in the analysis of the whole experiment, so they will not be discussed further here.

For total RT, the main effect of assignment was only marginally significant, $F(1, 56) = 2.99$, $p < .09$, $MSE = 458{,}928$, and it was not significant for accuracy, $F(1, 56) = 1.67$, $p < .20$, $MSE = 0.068$. Assignment did not figure in any significant interactions for RT. The main effect of assignment was significant for movement time, $F(1, 56) = 12.02$, $p < .0010$, $MSE = 277{,}197$, as the movement part of compatible responses was considerably faster than the movement part of incompatible responses (mean movement time = 299 vs. 431 ms for compatible and incompatible responses, respectively). This movement time result suggests the presence of a compatibility effect. However, for lift time, the main effect of assignment was not significant, $F(1, 56) = 1.83$, $p < .18$, $MSE = 233{,}641$, but, numerically at least, the lift part of compatible responses was *slower* than the lift part of incompatible responses (mean lift time = 386 vs. 339 ms for compatible and incompatible responses, respectively), if anything suggesting a *reverse* compatibility effect for lift time.

For RT there was no significant effect of response type, nor did response type figure in any significant interactions. The main effect of response type was significant for movement time, with near movements faster than far movements [mean movement time = 322 vs. 407 ms for near and far, respectively; $F(1, 56) = 5.03$, $p < .0289$, $MSE = 277{,}197$]. None of the interactions of assignment or response type with congruency, with separation or with cue dimension was significant for movement time. For lift time, however, the main effect of assignment, already described, was qualified by the significant Assignment x Congruency interaction, $F(1, 56) = 4.59$, $p < .0364$, $MSE = 3{,}439$ (see Figure 8). The lift part of compatible responses to congruent stimuli was faster than the lift part of responses to incongruent stimuli (mean lift time = 372 vs. 400 ms for congruent and incongruent stimuli, respectively). A similar pattern resulted for the lift part of incompatible responses (bottom line, Figure 8), where reactions to congruent stimuli were slightly faster than reactions to incongruent stimuli (mean lift time = 334 vs. 344 ms for congruent and incongruent stimuli, respectively). Note that in all cases the incompatible lift times were *faster* than the lift times for compatible responses.

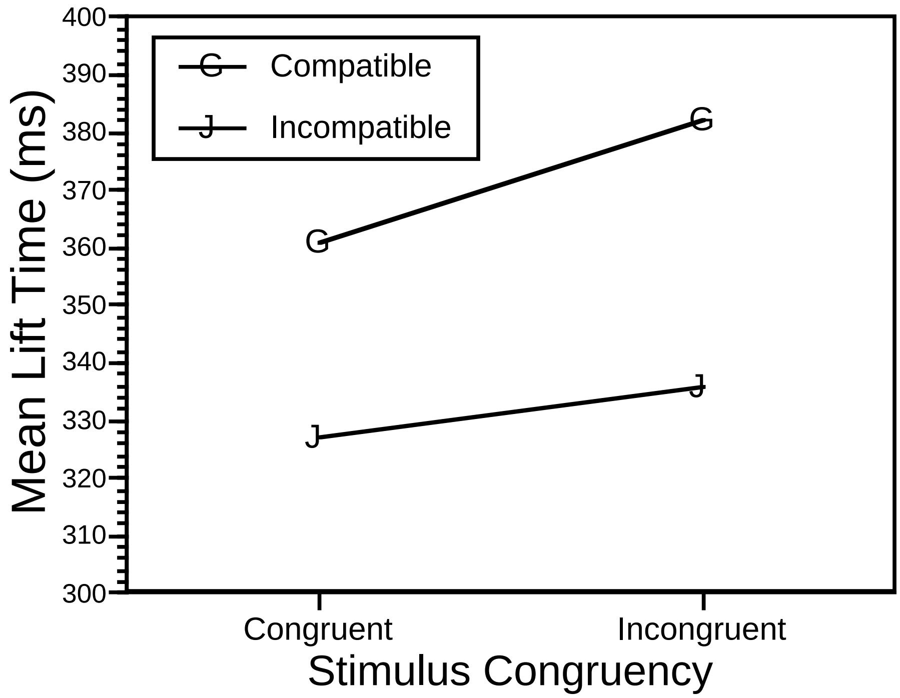

FIGURE 8. Mean lift time results for the first session in Experiment 2 as a function of assignment and congruency.

For accuracy of the total responses, in addition to the results already described the Assignment x Cue Dimension x Response Type interaction reached significance, $F(1, 56) = 4.02$, $p < .0497$, $MSE = 0.0684$ (see Figure 9). When responding with a compatible assignment (left side of Figure 9), the accuracy of position responses was higher for near responses than for far responses (95.5 vs. 92.8%, respectively), whereas the accuracy of direction responses was considerably lower for near responses than for far responses (86.3 vs. 92.4%, respectively). When responding with an incompatible assignment (right side of Figure 9), the accuracy of position responses was almost identical for near and for far response types (94.6 vs. 94.7% for near and far responses, respectively), and accuracy for direction responses was higher for near than for far responses (96.9 vs. 90.1%, respectively).

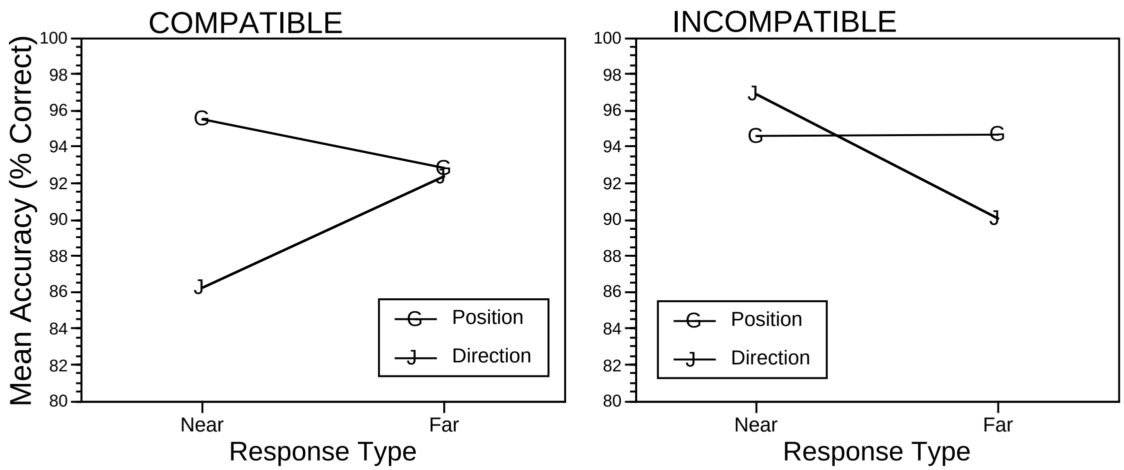

FIGURE 9. Mean accuracy results for the first session in Experiment 2 as a function of assignment, cue dimension and response type.

Discussion

The pattern of results with respect to cue dimension, congruency and separation was identical to Experiment 1, which is not surprising since the stimuli were not changed from Experiment 1 to Experiment 2. It seems clear that the two dimensions of pitch and pitch change influence the perception of and responding to one another. The only change with regard to any of the stimulus factors from Experiment 1 to Experiment 2 was that subjects only responded to one or the other of the cue dimensions; this had no effect on the overall pattern of results.

Despite efforts to create a truly vertical response set, there were only hints of the S-R compatibility effects that were expected to result from the interaction of the stimulus set and the response set, had pitch been treated spatially. The main effect of assignment for movement times might seem to indicate a compatibility effect arising from the interaction of pitch and the response set. However, the hint of a reverse compatibility effect for lift times makes it unclear how to interpret the main effect of assignment for movement times. Much of the previous research on spatial compatibility effects has shown that these effects arise during the response selection stage of processing, rather than during the response production or response completion stage (e.g., Proctor & Reeve, 1990). In the present experiment, the response selection stage should precede the movement, and therefore compatibility effects would have their effects more on lift times than on movement times. However, subjects may have lifted their finger before or during response selection, thereby mixing the response selection and response production stages of processing into the movement time.

Perhaps more could be done to create an even more compellingly vertical response set, but it is difficult to imagine how. It is possible that a different sort of response action, such as the deflection of a joystick would result in different S-R effects, but it appears more likely that a true absence of an assignment effect for changing pitches is not the result of quirks in the response set. S-R compatibility effects are so strong and prevalent in such a range of other tasks (e.g., Proctor & Reeve, 1990) that it is more likely due to the nature of the task or the stimuli that strong compatibility effects were not obtained. Possible accounts for the observed lack of compatibility effects will be considered in the General Discussion.

The results of Experiment 2 showed that the response type (near or far responses) and the order in which the subject used those response types, interacted with assignment, cue dimension and congruency. Although the stimulus dimensions and S-R assignments were the main focus in Experiment 2, these order effects are also interesting. In terms of response type and the order in which the two response types are used, there are two competing factors. First, because the subject completed a large number of trials with one response type (180 trials, including practice), the second response type should result in faster RTs due to practice with the task. If the second response type is to the farther buttons, this speed-up should help to overcome the longer RTs associated with the greater movement distances. If the second response type is to the nearer buttons, then the speed-up due to practice should add to the speed-up due to the shorter response distance, resulting in a considerably faster response than in the first (far) response type. This overall speed-up also depends on other factors in the task, such as the assignment of stimuli to responses. In the case of the compatible assignment (left side of Figure 5), it seems that the longer movement time is not overcome by the increased speed due to practice. However, in the incompatible assignment (right side of Figure 5, bottom arrow), the practice effects seem to be more beneficial than the increased distance is detrimental. A similar pattern is observed for the interactions of response type and order with cue dimension and with congruency. When the cue dimension was position (in the Cue Dimension x Response Type x Order interaction) or when responses were to congruent stimuli (in the Congruency x Response Type x Order interaction), the far responses were slower than the near responses, but the effects of practice helped to reduce the difference in RTs between near and far responses. However, when the cue dimension was direction (in the Cue Dimension x Response Type x Order interaction), or when responses were to incongruent stimuli (in the Congruency x Response Type x Order interaction), when far responses are performed second, RTs were comparable to those for near responses. That is, the speed-up in RT that results from practice was greater than the slowing effect of moving farther to respond.

In all of the interactions involving response type, order and a third factor, it was the more difficult task (i.e., the incompatible responses, the direction responses and the responses to incongruent stimuli), that showed evidence of practice effects overcoming the slowdown due to the farther responses. This similarity seems to indicate that the best way to train someone to perform these sorts of tasks depends both on how much effect practice has on the task, and the nature of the final task. For example, if the task involves compatible responses and the desired final motion is relatively far from the home button, it does not much matter whether the subject first practices with a near response, or the far response is performed without prior practice (only a 1-ms difference in the present experiment). However, if the final response is incompatible, then training with a near response will result in positive transfer to a far response.

GENERAL DISCUSSION

Designing the displays and the controls through which an operator interacts with a system requires an understanding of how the stimuli in the displays are perceived and how the information transmitted to the operator is translated into control actions. As auditory displays become more common it is increasingly important to understand the perception of complex and dynamic auditory stimuli and how the information contained in the various dimensions of these stimuli influences performance.

The research presented here examined the manner in which the auditory dimensions of pitch and pitch change interact to influence performance in a selective listening task that is typical of what might be required when using an auditory display. In particular, this research investigated congruency and compatibility effects with dynamic auditory stimuli, namely tones that become higher and lower in pitch.

One major question of interest here was whether the auditory dimensions of pitch and pitch change interact to influence responding to either dimension. The results of both Experiments 1 and 2 showed that responding to the onset pitch of a sound is faster than responding to the direction of pitch change of that sound. However, subjects were unable to listen to either aspect of the sounds in a completely selective manner, in that the direction of pitch change influenced pitch judgments, and vice versa. In other words, there appeared to be cross-talk (e.g., Melara & O'Brien, 1990) between the two stimulus dimensions, such that each dimension influenced either the perceptual or judgment processes underlying responses to the other dimension.

The intrusion of the information of one dimension onto judgments regarding the other dimension was not symmetrical in the present experiments, in that pitch information had a greater influence on responses to direction of pitch change than direction information had on pitch judgments. However, in both cases, when the two dimensions provided congruent information (e.g., a high pitch also became higher in pitch) responses were faster than if the two dimensions provided incongruent information (e.g., a high pitch became lower in pitch).

It was also observed that the congruency effect was fairly uniform for pitch judgments across the range of stimuli. However, for pitch-change judgments, responses to the stimuli which were more extreme in pitch (as compared to the average pitch of the set) were more influenced by irrelevant pitch information. Thus, these results suggest that for the design of auditory displays, the nature of the task should be considered in deciding upon the range of stimuli to use. In particular, if pitch is the dimension of interest, then the stimulus set should be widely separated in pitch. If, however, onset pitch is to be ignored, and it is the change in pitch that is to be attended, the stimuli should all be in a smaller pitch range, to lessen the effects of the intrusion of irrelevant pitch information onto direction judgments.

If pitch is treated by listeners in a spatial way, as is suggested by the common use of spatial descriptors for pitch in everyday language and by previous findings of S-R compatibility and Simon effects involving pitch (Mudd, 1963; Simon & Rudell, 1967), spatial S-R compatibility effects should be apparent when pitch is assigned to spatial responses. For this reason, the overall lack of strong S-R compatibility effects in both Experiments 1 and 2 was surprising. It should be noted that previous demonstrations of a Simon effect with pitch (Simon & Rudell, 1967) were conducted in a task in which the sounds were presented from speakers that were located above or below a reference point.

It may be that the use of separate speaker locations has the effect of making the quasi-spatial aspect of pitch more salient. In a similar way, the pegboard responses in Mudd's (1963) study actually required the subject to indicate a spatial correspondence between two pitches, which certainly would increase the salience of the spatial aspect of pitch. In the present work, however, all sounds were presented from one speaker, which perhaps minimized the spatial quality of the stimuli. Further work is underway to determine whether the use of one versus two speakers is the reason for the different outcomes with respect to effects of S-R assignments.

If compatibility effects are present between pitch and vertically arranged responses, but are simply difficult to produce, they are of limited interest. However, as mentioned, other studies have found some spatial compatibility effects with simple pitches. Perhaps, then, it is something particular about dynamic auditory stimuli that causes the lack of S-R compatibility effects. For example, perhaps the changes in pitch cause the listener to focus more on the relative auditory aspects of the pitches, and process them in a more "sound-specific" way. Pitch and pitch change would both be treated within the same conceptual framework (i.e., they would still be in the same conceptual "space", in the same way that hue and saturation are both considered part of the same "color space"), but this would no longer be tied so closely to the positioning of the sounds in the physical world. There is no a priori reason to think that the information extracted by using this more focused strategy of listening to pitch would interact with the physical arrangement of responses (or with any non-pitch dimension within the same stimulus or an attribute of another stimulus). The resulting dissociation of pitch and vertical position could well result in the sounds being treated as less "spatial" in the sense of vertical position. This in turn would result in the lack of a spatial compatibility effect.

The default mode of auditory perception may be to listen generally, or holistically to a sound, as could be the case in the present experiments, but the requirements of the task may cause the subject to change this listening strategy (even without the intention to do so). This general line of reasoning is supported by the findings of Bregman and Walker (1993), where subjects were presented with brief “chirps” made up of three concurrent pitch components that were not unlike the stimuli used in the present experiments, and then asked to perform either holistic or analytic listening tasks. While the results of their work indicated that it was quite possible to attend selectively to one of the three components of the stimuli, Bregman and Walker found that the default mode of listening for most people was to attend to the whole sound, rather than to just one element within it. That is, once the sound was perceived as a unified whole, it was difficult to listen analytically again. Neither Bregman and Walker’s study nor the present research specifically examined whether the analytic listening strategy is learned or developed. It may be that people who listen more “holistically” would treat pitch in a more spatial way, and thus be more likely to exhibit spatial compatibility effects when responding to pitch with a vertical response set. This possible influence of listening strategy on compatibility effects has yet to be studied.

Although the dimension of pitch is often referred to in spatial terms in “western” culture, there are cultures that do not refer to pitch in the same terms used to describe vertical position. Kubik (1975) points out that in many Bantu languages the words “small” and “large” are used to describe what English speakers call “high” and “low” pitches, respectively. This characterization presumably comes from the size of the object that typically produces a given class of sounds. Such use of different descriptors for pitch provides more support for the theory that treating pitch as a spatial concept is learned, and possibly cultural. Further research in the area of dynamic auditory stimuli as used to guide speeded responses should examine whether there are different types of listening strategies, and possibly different types of listeners, which may result in differing performance on tasks involving selective listening and rapid responding.

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APPENDIX A: Stimulus Parameters

The auditory stimuli were 250-ms pitch glides composed of ten intermediate steps. The initial and final frequencies are presented in Table A-1. The changes to the stimuli were equal in terms of log-frequency, so that the perceived pitch change should be approximately equal for all stimuli (Moore, 1989).

The frequencies were calculated with the following equation:

$$f = 10^{N} \qquad \text{(Eq. A.1)}$$

where f is the frequency of the sound, and N is the “exponent” listed in Table A-1. For example, Stimulus 3 has the onset frequency of: $f = 10^{(3)} = 1000$ Hz.

TABLE A-1. Stimulus parameters.

	Onset		Offset	
Stimulus	Exponent	Frequency (Hz)	Exponent	Frequency (Hz)
1	3.2	1585	3.4	2512
2	3.1	1259	3.3	1995
3	3.0	1000	3.2	1585
4	3.4	2512	3.2	1585
5	3.3	1995	3.1	1259
6	3.2	1585	3.0	1000
7	2.7	501	2.9	794
8	2.6	398	2.8	631
9	2.5	316	2.7	501
10	2.9	794	2.7	501
11	2.8	631	2.6	398
12	2.7	501	2.5	316

APPENDIX B: ANOVA Tables for Experiment 1

TABLE B-1. Factor name abbreviations for Experiment 1.

Factor Name	Abbreviation
Assignment	AS
Order	OR
Cue Dimension	CU
Response Type	RE
Block	BL
Congruency	CO
Separation	SE
Subject	SU

TABLE B-2. ANOVA Table for Mean Correct Reaction Time in Experiment 1.

Tests of Hypotheses using the Anova MS for SU(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
AS	1	722102.5916	722102.5916	0.87	0.3604
OR	1	1775587.0195	1775587.0195	2.14	0.1566
AS*OR	1	1171760.3426	1171760.3426	1.41	0.2465

Tests of Hypotheses using the Anova MS for SU*CU(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CU	1	4089231.5661	4089231.5661	13.00	0.0014
AS*CU	1	14137.1281	14137.1281	0.04	0.8339
OR*CU	1	545049.3224	545049.3224	1.73	0.2004
AS*OR*CU	1	56703.4508	56703.4508	0.18	0.6749

Tests of Hypotheses using the Anova MS for SU*BL(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL	1	0.0000	0.0000	0.00	0.9990
AS*BL	1	6709.0959	6709.0959	0.36	0.5539
OR*BL	1	38927.8070	38927.8070	2.00	0.1610
AS*OR*BL	1	1655.7278	1655.7278	0.09	0.7681

Tests of Hypotheses using the Anova MS for SU*CU*BL(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CU*BL	1	16235.9154	16235.9154	1.08	0.3084
AS*CU*BL	1	30254.4836	30254.4836	2.02	0.1683
OR*CU*BL	1	55414.9768	55414.9768	3.70	0.0665
AS*OR*CU*BL	1	12491.4890	12491.4890	0.83	0.3705

Tests of Hypotheses using the Anova MS for SU*CO(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO	1	442026.6380	442026.6380	11.80	0.0022
AS*CO	1	32.3435	32.3435	0.00	0.9760
OR*CO	1	17673.9648	17673.9648	0.47	0.4900
AS*OR*CO	1	2411.2715	2411.2715	0.06	0.8019

Tests of Hypotheses using the Anova MS for SU*BL*CO(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO	1	69.7517	69.7517	0.01	0.9300
AS*BL*CO	1	173.8884	173.8884	0.01	0.9047
OR*BL*CO	1	16239.3329	16239.3329	1.37	0.2537
AS*OR*BL*CO	1	2548.7980	2548.7980	0.21	0.6473

Tests of Hypotheses using the Anova MS for SU*CU*CO(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CU*CO	1	43271.3925	43271.3925	2.70	0.1130
AS*CU*CO	1	4401.1033	4401.1033	0.27	0.6053
OR*CU*CO	1	3075.0585	3075.0585	0.19	0.6655
AS*OR*CU*CO	1	3807.9083	3807.9083	0.24	0.6306

Table continues...

Tests of Hypotheses using the Anova MS for SU*CU*BL*CO(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CU*BL*CO	1	3222.3942	3222.3942	0.38	0.5418
AS*CU*BL*CO	1	271.1903	271.1903	0.03	0.8590
OR*CU*BL*CO	1	1831.1769	1831.1769	0.22	0.6450
AS*OR*CU*BL*CO	1	11111.9117	11111.9117	1.30	0.2610

Tests of Hypotheses using the Anova MS for SU*SE(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SE	2	482152.6631	241076.3316	25.40	0.0010
AS*SE	2	7230.5400	3615.2700	0.38	0.6852
OR*SE	2	27706.1183	13853.0591	1.46	0.2424
AS*OR*SE	2	35358.8269	17679.4134	1.86	0.1662

Tests of Hypotheses using the Anova MS for SU*CO*SE(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO*SE	2	138275.2152	69137.6076	8.45	0.0007
AS*CO*SE	2	11231.6233	5615.8116	0.69	0.5084
OR*CO*SE	2	5194.9763	2597.4882	0.32	0.7296
AS*OR*CO*SE	2	2498.3932	1249.1966	0.15	0.8589

Tests of Hypotheses using the Anova MS for SU*BL*SE(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*SE	2	38522.1100	19261.0550	2.88	0.0659
AS*BL*SE	2	2746.4903	1373.2451	0.21	0.8151
OR*BL*SE	2	4831.8893	2415.9447	0.36	0.6986
AS*OR*BL*SE	2	479.8347	239.9174	0.04	0.9648

Tests of Hypotheses using the Anova MS for SU*BL*CO*SE(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO*SE	2	9619.8086	4809.9043	0.86	0.4315
AS*BL*CO*SE	2	1217.9901	608.9950	0.11	0.8976
OR*BL*CO*SE	2	14116.7043	7058.3522	1.26	0.2942
AS*OR*BL*CO*SE	2	6382.6229	3191.3115	0.50	0.5700

Tests of Hypotheses using the Anova MS for SU*CU*SE(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CU*SE	2	655603.0638	327801.5319	42.03	0.0001
AS*CU*SE	2	960.6727	480.3363	0.06	0.9403
OR*CU*SE	2	109995.4624	54997.7312	7.05	0.0021
AS*OR*CU*SE	2	14833.6730	7416.8365	0.95	0.3936

Tests of Hypotheses using the Anova MS for SU*CU*CO*SE(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CU*CO*SE	2	181798.8472	90899.4236	13.41	0.0001
AS*CU*CO*SE	2	8216.6369	4108.3184	0.61	0.5496
OR*CU*CO*SE	2	238.9155	119.4578	0.02	0.9825
AS*OR*CU*CO*SE	2	25120.3061	12560.1531	1.85	0.1678

Table continues...

Tests of Hypotheses using the Anova MS for SU*CU*BL*SE(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CU*BL*SE	2	21539.0710	10769.5355	1.33	0.2740
AS*CU*BL*SE	2	776.2336	388.1168	0.05	0.9532
OR*CU*BL*SE	2	36234.5073	18117.2536	2.24	0.1177
AS*OR*CU*BL*SE	2	8857.1992	4428.5996	0.55	0.5823

Tests of Hypotheses using the Anova MS for SU*CU*BL*CO*SE(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CU*BL*CO*SE	2	6921.2209	3460.6104	0.61	0.5457
AS*CU*BL*CO*SE	2	16715.3273	8357.6637	1.48	0.2376
OR*CU*BL*CO*SE	2	8615.6648	4307.8324	0.76	0.4716
AS*OR*CU*BL*CO*SE	2	6157.7253	3078.8627	0.55	0.5830

TABLE B-3. ANOVA Table for Accuracy in Experiment 1.

Tests of Hypotheses using the Anova MS for SU(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
AS	1	0.0704	0.0704	0.95	0.3382
OR	1	0.0300	0.0300	0.41	0.5295
AS*OR	1	0.0483	0.0483	0.65	0.4264

Tests of Hypotheses using the Anova MS for SU*CU(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CU	1	0.4148	0.4148	7.20	0.0130
AS*CU	1	0.1576	0.1576	2.74	0.1112
OR*CU	1	0.0673	0.0673	1.17	0.2904
AS*OR*CU	1	0.0099	0.0099	0.17	0.6820

Tests of Hypotheses using the Anova MS for SU*BL(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL	1	0.0202	0.0202	7.19	0.0131
AS*BL	1	0.0145	0.0145	5.17	0.0322
OR*BL	1	0.0002	0.0002	0.08	0.7840
AS*OR*BL	1	0.0138	0.0138	4.92	0.0363

Tests of Hypotheses using the Anova MS for SU*CU*BL(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CU*BL	1	0.0042	0.0042	0.61	0.4428
AS*CU*BL	1	0.0467	0.0467	6.85	0.0151
OR*CU*BL	1	0.0042	0.0042	0.62	0.4406
AS*OR*CU*BL	1	0.0405	0.0405	5.94	0.0226

Tests of Hypotheses using the Anova MS for SU*CO(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO	1	0.2884	0.2884	10.77	0.0032
AS*CO	1	0.0194	0.0194	0.72	0.4034
OR*CO	1	0.0230	0.0230	0.86	0.3636
AS*OR*CO	1	0.0112	0.0112	0.42	0.5245

Tests of Hypotheses using the Anova MS for SU*BL*CO(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO	1	0.0015	0.0015	0.39	0.5370
AS*BL*CO	1	0.0002	0.0002	0.05	0.8299
OR*BL*CO	1	0.0004	0.0004	0.10	0.7517
AS*OR*BL*CO	1	0.0025	0.0025	0.65	0.4265

Tests of Hypotheses using the Anova MS for SU*CU*CO(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CU*CO	1	0.0874	0.0874	8.46	0.0077
AS*CU*CO	1	0.0426	0.0426	4.12	0.0535
OR*CU*CO	1	0.0007	0.0007	0.07	0.8000
AS*OR*CU*CO	1	0.0012	0.0012	0.11	0.7401

Table continues...

Tests of Hypotheses using the Anova MS for SU*CU*BL*CO(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CU*BL*CO	1	0.0019	0.0019	0.35	0.5569
AS*CU*BL*CO	1	0.0066	0.0066	1.23	0.2788
OR*CU*BL*CO	1	0.0102	0.0102	1.91	0.1799
AS*OR*CU*BL*CO	1	0.0003	0.0003	0.06	0.8124

Tests of Hypotheses using the Anova MS for SU*SE(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SE	2	0.1375	0.0688	13.61	0.0001
AS*SE	2	0.0024	0.0012	0.23	0.7928
OR*SE	2	0.0067	0.0034	0.67	0.5183
AS*OR*SE	2	0.0044	0.0022	0.44	0.6464

Tests of Hypotheses using the Anova MS for SU*CO*SE(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO*SE	2	0.0718	0.0359	5.48	0.0072
AS*CO*SE	2	0.0615	0.0308	4.69	0.0138
OR*CO*SE	2	0.0050	0.0025	0.38	0.6843
AS*OR*CO*SE	2	0.0251	0.0126	1.92	0.1583

Tests of Hypotheses using the Anova MS for SU*BL*SE(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*SE	2	0.0089	0.0044	0.98	0.3831
AS*BL*SE	2	0.0024	0.0012	0.26	0.7719
OR*BL*SE	2	0.0091	0.0045	1.00	0.3769
AS*OR*BL*SE	2	0.0012	0.0006	0.13	0.8815

Tests of Hypotheses using the Anova MS for SU*BL*CO*SE(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO*SE	2	0.0203	0.0102	3.45	0.0400
AS*BL*CO*SE	2	0.0267	0.0133	4.52	0.0159
OR*BL*CO*SE	2	0.0085	0.0043	1.45	0.2453
AS*OR*BL*CO*SE	2	0.0200	0.0100	3.38	0.0421

Tests of Hypotheses using the Anova MS for SU*CU*SE(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CU*SE	2	0.4629	0.2314	47.49	0.0001
AS*CU*SE	2	0.0026	0.0013	0.27	0.7665
OR*CU*SE	2	0.0205	0.0102	2.10	0.1337
AS*OR*CU*SE	2	0.0281	0.0140	2.88	0.0658

Tests of Hypotheses using the Anova MS for SU*CU*CO*SE(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CU*CO*SE	2	0.1764	0.0882	8.75	0.0006
AS*CU*CO*SE	2	0.0393	0.0196	1.95	0.1538
OR*CU*CO*SE	2	0.0529	0.0264	2.62	0.0832
AS*OR*CU*CO*SE	2	0.0314	0.0157	1.56	0.2215

Table continues...

Tests of Hypotheses using the Anova MS for SU*CU*BL*SE(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CU*BL*SE	2	0.0202	0.0101	1.68	0.1967
AS*CU*BL*SE	2	0.0136	0.0068	1.14	0.3292
OR*CU*BL*SE	2	0.0002	0.0001	0.01	0.9862
AS*OR*CU*BL*SE	2	0.0119	0.0059	0.99	0.3790

Tests of Hypotheses using the Anova MS for SU*CU*BL*CO*SE(AS*OR) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CU*BL*CO*SE	2	0.0276	0.0138	3.45	0.0399
AS*CU*BL*CO*SE	2	0.0248	0.0124	3.10	0.0543
OR*CU*BL*CO*SE	2	0.0026	0.0013	0.33	0.7202
AS*OR*CU*BL*CO*SE	2	0.0122	0.0061	1.52	0.2289

APPENDIX C: ANOVA Tables for Experiment 2

TABLE C-1. Factor name abbreviations for Experiment 2.

Factor Name	Abbreviation
Order	OR
Assignment	AS
Cue Dimension	CU
Response Type	RE
Block	BL
Congruency	CO
Separation	SE
Subject	SU

TABLE C-2. ANOVA Table for Mean Correct Total Reaction Time in Experiment 2.

Tests of Hypotheses using the Anova MS for SU(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
OR	1	530372.9667	530372.9667	0.69	0.4102
AS	1	1426079.9329	1426079.9329	1.85	0.1791
CU	1	9347563.7535	9347563.7535	12.14	0.0010
OR*AS	1	1199066.8222	1199066.8222	1.56	0.2173
OR*CU	1	144403.4933	144403.4933	0.19	0.6667
AS*CU	1	323758.9993	323758.9993	0.42	0.5194
OR*AS*CU	1	59465.6395	59465.6395	0.08	0.7821

Tests of Hypotheses using the Anova MS for SU*RE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE	1	1312341.1937	1312341.1937	43.06	0.0001
OR*RE	1	690546.2357	690546.2357	22.66	0.0001
AS*RE	1	84759.5637	84759.5637	2.78	0.1010
CU*RE	1	43688.4995	43688.4995	1.43	0.2363
OR*AS*RE	1	214297.8572	214297.8572	7.03	0.0104
OR*CU*RE	1	411407.7578	411407.7578	13.50	0.0005
AS*CU*RE	1	43488.7080	43488.7080	1.43	0.2373
OR*AS*CU*RE	1	3.9073	3.9073	0.00	0.9910

Tests of Hypotheses using the Anova MS for SU*BL(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL	1	163105.45617	163105.45617	5.77	0.0197
OR*BL	1	2402.84410	2402.84410	0.08	0.7717
AS*BL	1	1543.57281	1543.57281	0.05	0.8161
CU*BL	1	74610.62420	74610.62420	2.64	0.1099
OR*AS*BL	1	1173.36952	1173.36952	0.04	0.8393
OR*CU*BL	1	2582.32113	2582.32113	0.09	0.7636
AS*CU*BL	1	65318.62870	65318.62870	2.31	0.1342
OR*AS*CU*BL	1	187.49726	187.49726	0.01	0.9354

Tests of Hypotheses using the Anova MS for SU*CO(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO	1	1461223.4397	1461223.4397	47.48	0.0001
OR*CO	1	66345.6444	66345.6444	2.16	0.1476
AS*CO	1	34200.2267	34200.2267	1.11	0.2963
CU*CO	1	315493.2562	315493.2562	10.25	0.0023
OR*AS*CO	1	69494.1246	69494.1246	2.26	0.1385
OR*CU*CO	1	30622.8255	30622.8255	0.99	0.3228
AS*CU*CO	1	2.1750	2.1750	0.00	0.9933
OR*AS*CU*CO	1	213.3410	213.3410	0.01	0.9339

Tests of Hypotheses using the Anova MS for SU*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SE	2	371864.9864	185932.4932	16.69	0.0001
OR*SE	2	48821.8528	24410.9264	2.19	0.1166
AS*SE	2	23377.6730	11688.8365	1.05	0.3537
CU*SE	2	1394581.2568	697290.6284	62.59	0.0001
OR*AS*SE	2	30710.4166	15355.2083	1.38	0.2563
OR*CU*SE	2	60493.9570	30246.9785	2.71	0.0706
AS*CU*SE	2	31752.0223	15876.0112	1.42	0.2448
OR*AS*CU*SE	2	48751.4494	24375.7247	2.19	0.1169

Table continues...

Tests of Hypotheses using the Anova MS for SU*RE*BL(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*BL	1	606.682198	606.682198	0.03	0.8609
OR*RE*BL	1	89862.038686	89862.038686	4.59	0.0365
AS*RE*BL	1	12322.091697	12322.091697	0.63	0.4308
CU*RE*BL	1	1831.023073	1831.023073	0.09	0.7608
OR*AS*RE*BL	1	3874.743211	3874.743211	0.20	0.6580
OR*CU*RE*BL	1	7.304379	7.304379	0.00	0.9847
AS*CU*RE*BL	1	1314.900803	1314.900803	0.07	0.7964
OR*AS*CU*RE*BL	1	39379.951231	39379.951231	2.01	0.1615

Tests of Hypotheses using the Anova MS for SU*RE*CO(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*CO	1	665.723392	665.723392	0.08	0.7735
OR*RE*CO	1	38615.969474	38615.969474	4.85	0.0318
AS*RE*CO	1	5154.056497	5154.056497	0.65	0.4244
CU*RE*CO	1	13657.149370	13657.149370	1.72	0.1956
OR*AS*RE*CO	1	2206.380521	2206.380521	0.28	0.6006
OR*CU*RE*CO	1	14625.536334	14625.536334	1.84	0.1807
AS*CU*RE*CO	1	2226.089548	2226.089548	0.28	0.5990
OR*AS*CU*RE*CO	1	142.792588	142.792588	0.02	0.8939

Tests of Hypotheses using the Anova MS for SU*RE*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*SE	2	29175.516333	14587.758167	2.60	0.0788
OR*RE*SE	2	15003.624476	7501.812238	1.34	0.2668
AS*RE*SE	2	1797.400094	898.700047	0.16	0.8522
CU*RE*SE	2	3457.540146	1728.770073	0.31	0.7355
OR*AS*RE*SE	2	101.852860	50.926430	0.01	0.9910
OR*CU*RE*SE	2	15788.293050	7894.146525	1.41	0.2492
AS*CU*RE*SE	2	21782.121817	10891.060909	1.94	0.1483
OR*AS*CU*RE*SE	2	8518.418407	4259.209203	0.76	0.4705

Tests of Hypotheses using the Anova MS for SU*BL*CO(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO	1	20583.417806	20583.417806	2.90	0.0943
OR*BL*CO	1	6613.545392	6613.545392	0.93	0.3388
AS*BL*CO	1	8816.088628	8816.088628	1.24	0.2701
CU*BL*CO	1	1055.764766	1055.764766	0.15	0.7014
OR*AS*BL*CO	1	123.905545	123.905545	0.02	0.8954
OR*CU*BL*CO	1	8629.054956	8629.054956	1.21	0.2752
AS*CU*BL*CO	1	14978.732747	14978.732747	2.11	0.1521
OR*AS*CU*BL*CO	1	10490.005449	10490.005449	1.48	0.2295

Tests of Hypotheses using the Anova MS for SU*BL*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*SE	2	9066.693349	4533.346675	0.72	0.4875
OR*BL*SE	2	10746.790624	5373.395312	0.86	0.4272
AS*BL*SE	2	1176.638796	588.319398	0.09	0.9105
CU*BL*SE	2	2029.281922	1014.640961	0.16	0.8508
OR*AS*BL*SE	2	849.580735	424.790368	0.07	0.9345
OR*CU*BL*SE	2	13595.473553	6797.736777	1.08	0.3417
AS*CU*BL*SE	2	4003.184993	2001.592496	0.32	0.7274
OR*AS*CU*BL*SE	2	1594.086125	797.043063	0.13	0.8808

Table continues...

Tests of Hypotheses using the Anova MS for SU*CO*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO*SE	2	563008.44941	281504.22470	19.08	0.0001
OR*CO*SE	2	3967.96846	1983.98423	0.13	0.8743
AS*CO*SE	2	10757.34327	5378.67164	0.36	0.6953
CU*CO*SE	2	901036.10611	450518.05305	30.54	0.0001
OR*AS*CO*SE	2	363.04923	181.52461	0.01	0.9878
OR*CU*CO*SE	2	4980.12097	2490.06048	0.17	0.8449
AS*CU*CO*SE	2	4112.94481	2056.47241	0.14	0.8700
OR*AS*CU*CO*SE	2	42247.26376	21123.63188	1.43	0.2432

Tests of Hypotheses using the Anova MS for SU*RE*BL*CO(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*BL*CO	1	1922.3392423	1922.3392423	0.32	0.5715
OR*RE*BL*CO	1	9199.4734880	9199.4734880	1.55	0.2183
AS*RE*BL*CO	1	172.3895167	172.3895167	0.03	0.8653
CU*RE*BL*CO	1	1.8112421	1.8112421	0.00	0.9861
OR*AS*RE*BL*CO	1	3141.0054363	3141.0054363	0.53	0.4699
OR*CU*RE*BL*CO	1	435.2920710	435.2920710	0.07	0.7875
AS*CU*RE*BL*CO	1	2312.9761202	2312.9761202	0.39	0.5349
OR*AS*CU*RE*BL*CO	1	40.5019882	40.5019882	0.01	0.9344

Tests of Hypotheses using the Anova MS for SU*RE*BL*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*BL*SE	2	22403.442621	11201.721311	2.08	0.1293
OR*RE*BL*SE	2	26503.705249	13251.852624	2.46	0.0897
AS*RE*BL*SE	2	7216.113147	3608.056574	0.67	0.5133
CU*RE*BL*SE	2	56617.953088	28308.976544	5.26	0.0065
OR*AS*RE*BL*SE	2	17276.735382	8638.367691	1.61	0.2052
OR*CU*RE*BL*SE	2	9471.584842	4735.792421	0.88	0.4173
AS*CU*RE*BL*SE	2	8187.837929	4093.918964	0.76	0.4694
OR*AS*CU*RE*BL*SE	2	4712.104388	2356.052194	0.44	0.6463

Tests of Hypotheses using the Anova MS for SU*RE*CO*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*CO*SE	2	7365.556302	3682.778151	0.57	0.5675
OR*RE*CO*SE	2	8718.196563	4359.098282	0.67	0.5118
AS*RE*CO*SE	2	16431.655361	8215.827681	1.27	0.2848
CU*RE*CO*SE	2	1601.538001	800.769000	0.12	0.8837
OR*AS*RE*CO*SE	2	213.559989	106.779995	0.02	0.9836
OR*CU*RE*CO*SE	2	8011.413386	4005.706693	0.62	0.5402
AS*CU*RE*CO*SE	2	696.842560	348.421280	0.05	0.9476
OR*AS*CU*RE*CO*SE	2	9462.947127	4731.473564	0.73	0.4835

Tests of Hypotheses using the Anova MS for SU*BL*CO*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO*SE	2	2598.201228	1299.100614	0.21	0.8099
OR*BL*CO*SE	2	20840.661697	10420.330849	1.69	0.1884
AS*BL*CO*SE	2	17801.679359	8900.839680	1.45	0.2396
CU*BL*CO*SE	2	2119.562553	1059.781277	0.17	0.8419
OR*AS*BL*CO*SE	2	3574.634485	1787.317243	0.29	0.7484
OR*CU*BL*CO*SE	2	13265.461529	6632.730764	1.08	0.3437
AS*CU*BL*CO*SE	2	14891.106782	7445.553391	1.21	0.3019
OR*AS*CU*BL*CO*SE	2	18210.575723	9105.287862	1.48	0.2320

TABLE C-3. ANOVA Table for Accuracy in Experiment 2.

Tests of Hypotheses using the Anova MS for SU(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
OR	1	0.14176422	0.14176422	1.65	0.2036
AS	1	0.08694610	0.08694610	1.01	0.3181
CU	1	0.10117057	0.10117057	1.18	0.2818
OR*AS	1	0.15527757	0.15527757	1.81	0.1836
OR*CU	1	0.00108287	0.00108287	0.01	0.9109
AS*CU	1	0.01700218	0.01700218	0.20	0.6577
OR*AS*CU	1	0.33517037	0.33517037	3.91	0.0529

Tests of Hypotheses using the Anova MS for SU*RE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE	1	0.05509466	0.05509466	3.62	0.0623
OR*RE	1	0.20526558	0.20526558	13.48	0.0005
AS*RE	1	0.00455006	0.00455006	0.30	0.5868
CU*RE	1	0.00762828	0.00762828	0.50	0.4820
OR*AS*RE	1	0.03334201	0.03334201	2.19	0.1445
OR*CU*RE	1	0.05536116	0.05536116	3.64	0.0617
AS*CU*RE	1	0.02648839	0.02648839	1.74	0.1925
OR*AS*CU*RE	1	0.06279978	0.06279978	4.13	0.0470

Tests of Hypotheses using the Anova MS for SU*BL(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL	1	0.04348840	0.04348840	7.08	0.0102
OR*BL	1	0.01275924	0.01275924	2.08	0.1551
AS*BL	1	0.00011869	0.00011869	0.02	0.8899
CU*BL	1	0.02670636	0.02670636	4.35	0.0416
OR*AS*BL	1	0.00029350	0.00029350	0.05	0.8278
OR*CU*BL	1	0.01630706	0.01630706	2.65	0.1089
AS*CU*BL	1	0.00002730	0.00002730	0.00	0.9471
OR*AS*CU*BL	1	0.00000158	0.00000158	0.00	0.9873

Tests of Hypotheses using the Anova MS for SU*CO(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO	1	0.79571862	0.79571862	16.85	0.0001
OR*CO	1	0.00650235	0.00650235	0.14	0.7120
AS*CO	1	0.04598960	0.04598960	0.97	0.3280
CU*CO	1	0.15252886	0.15252886	3.23	0.0777
OR*AS*CO	1	0.03145412	0.03145412	0.67	0.4179
OR*CU*CO	1	0.01207334	0.01207334	0.26	0.6151
AS*CU*CO	1	0.00333087	0.00333087	0.07	0.7915
OR*AS*CU*CO	1	0.11313760	0.11313760	2.40	0.1273

Tests of Hypotheses using the Anova MS for SU*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SE	2	0.39761197	0.19880599	24.55	0.0001
OR*SE	2	0.04514821	0.02257411	2.79	0.0658
AS*SE	2	0.01503082	0.00751541	0.93	0.3983
CU*SE	2	1.33417602	0.66708801	82.39	0.0001
OR*AS*SE	2	0.00854169	0.00427084	0.53	0.5916
OR*CU*SE	2	0.05650806	0.02825403	3.49	0.0339
AS*CU*SE	2	0.10171529	0.05085765	6.28	0.0026
OR*AS*CU*SE	2	0.00110235	0.00055117	0.07	0.9342

Table continues...

Tests of Hypotheses using the Anova MS for SU*RE*BL(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*BL	1	0.00058855	0.00058855	0.12	0.7358
OR*RE*BL	1	0.01727258	0.01727258	3.38	0.0715
AS*RE*BL	1	0.00046950	0.00046950	0.09	0.7631
CU*RE*BL	1	0.00339664	0.00339664	0.66	0.4187
OR*AS*RE*BL	1	0.01689146	0.01689146	3.30	0.0746
OR*CU*RE*BL	1	0.00480206	0.00480206	0.94	0.3368
AS*CU*RE*BL	1	0.00050891	0.00050891	0.10	0.7537
OR*AS*CU*RE*BL	1	0.00020440	0.00020440	0.04	0.8423

Tests of Hypotheses using the Anova MS for SU*RE*CO(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*CO	1	0.00008011	0.00008011	0.01	0.9061
OR*RE*CO	1	0.06838947	0.06838947	11.98	0.0010
AS*RE*CO	1	0.02119949	0.02119949	3.71	0.0591
CU*RE*CO	1	0.00416255	0.00416255	0.73	0.3969
OR*AS*RE*CO	1	0.00018851	0.00018851	0.03	0.8565
OR*CU*RE*CO	1	0.01219826	0.01219826	2.14	0.1494
AS*CU*RE*CO	1	0.00005256	0.00005256	0.01	0.9239
OR*AS*CU*RE*CO	1	0.00037636	0.00037636	0.07	0.7983

Tests of Hypotheses using the Anova MS for SU*RE*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*SE	2	0.00188725	0.00094363	0.23	0.7970
OR*RE*SE	2	0.00441157	0.00220579	0.53	0.5893
AS*RE*SE	2	0.00019020	0.00009510	0.02	0.9774
CU*RE*SE	2	0.00265675	0.00132838	0.32	0.7268
OR*AS*RE*SE	2	0.00219803	0.00109901	0.26	0.7679
OR*CU*RE*SE	2	0.02656243	0.01328122	3.20	0.0445
AS*CU*RE*SE	2	0.00102437	0.00051219	0.12	0.8840
OR*AS*CU*RE*SE	2	0.01213121	0.00606561	1.46	0.2364

Tests of Hypotheses using the Anova MS for SU*BL*CO(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO	1	0.00296076	0.00296076	0.58	0.4490
OR*BL*CO	1	0.00254457	0.00254457	0.50	0.4826
AS*BL*CO	1	0.00368333	0.00368333	0.72	0.3987
CU*BL*CO	1	0.00037088	0.00037088	0.07	0.7883
OR*AS*BL*CO	1	0.00215990	0.00215990	0.42	0.5176
OR*CU*BL*CO	1	0.00127749	0.00127749	0.25	0.6184
AS*CU*BL*CO	1	0.00603113	0.00603113	1.18	0.2812
OR*AS*CU*BL*CO	1	0.00249173	0.00249173	0.49	0.4871

Tests of Hypotheses using the Anova MS for SU*BL*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*SE	2	0.02378741	0.01189370	2.55	0.0823
OR*BL*SE	2	0.01673418	0.00836709	1.80	0.1706
AS*BL*SE	2	0.00874772	0.00437386	0.94	0.3940
CU*BL*SE	2	0.00090768	0.00045384	0.10	0.9072
OR*AS*BL*SE	2	0.00847399	0.00423699	0.91	0.4055
OR*CU*BL*SE	2	0.01178862	0.00589431	1.27	0.2860
AS*CU*BL*SE	2	0.00987469	0.00493735	1.06	0.3498
OR*AS*CU*BL*SE	2	0.00580705	0.00290352	0.62	0.5379

Table continues...

Tests of Hypotheses using the Anova MS for SU*CO*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO*SE	2	0.18231788	0.09115894	5.71	0.0044
OR*CO*SE	2	0.02637397	0.01318698	0.83	0.4406
AS*CO*SE	2	0.01082714	0.00541357	0.34	0.7132
CU*CO*SE	2	0.64082162	0.32041081	20.06	0.0001
OR*AS*CO*SE	2	0.00393611	0.00196806	0.12	0.8842
OR*CU*CO*SE	2	0.00386016	0.00193008	0.12	0.8863
AS*CU*CO*SE	2	0.04899275	0.02449638	1.53	0.2202
OR*AS*CU*CO*SE	2	0.00720754	0.00360377	0.23	0.7984

Tests of Hypotheses using the Anova MS for SU*RE*BL*CO(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*BL*CO	1	0.01377129	0.01377129	3.13	0.0824
OR*RE*BL*CO	1	0.00008267	0.00008267	0.02	0.8915
AS*RE*BL*CO	1	0.00015510	0.00015510	0.04	0.8518
CU*RE*BL*CO	1	0.00181017	0.00181017	0.41	0.5240
OR*AS*RE*BL*CO	1	0.01570756	0.01570756	3.57	0.0641
OR*CU*RE*BL*CO	1	0.00002039	0.00002039	0.00	0.9460
AS*CU*RE*BL*CO	1	0.00929531	0.00929531	2.11	0.1518
OR*AS*CU*RE*BL*CO	1	0.00000030	0.00000030	0.00	0.9935

Tests of Hypotheses using the Anova MS for SU*RE*BL*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*BL*SE	2	0.00345751	0.00172875	0.46	0.6345
OR*RE*BL*SE	2	0.00281639	0.00140819	0.37	0.6901
AS*RE*BL*SE	2	0.00292283	0.00146141	0.39	0.6806
CU*RE*BL*SE	2	0.00509528	0.00254764	0.67	0.5121
OR*AS*RE*BL*SE	2	0.00749107	0.00374554	0.99	0.3749
OR*CU*RE*BL*SE	2	0.00593798	0.00296899	0.78	0.4588
AS*CU*RE*BL*SE	2	0.00566303	0.00283151	0.75	0.4756
OR*AS*CU*RE*BL*SE	2	0.01331576	0.00665788	1.76	0.1769

Tests of Hypotheses using the Anova MS for SU*RE*CO*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*CO*SE	2	0.00103815	0.00051907	0.12	0.8891
OR*RE*CO*SE	2	0.00782621	0.00391310	0.89	0.4146
AS*RE*CO*SE	2	0.01769242	0.00884621	2.01	0.1393
CU*RE*CO*SE	2	0.00576100	0.00288050	0.65	0.5223
OR*AS*RE*CO*SE	2	0.01746201	0.00873101	1.98	0.1429
OR*CU*RE*CO*SE	2	0.04035977	0.02017988	4.58	0.0123
AS*CU*RE*CO*SE	2	0.00426556	0.00213278	0.48	0.6178
OR*AS*CU*RE*CO*SE	2	0.00764223	0.00382111	0.87	0.4232

Tests of Hypotheses using the Anova MS for SU*BL*CO*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO*SE	2	0.01861627	0.00930813	1.96	0.1457
OR*BL*CO*SE	2	0.00630600	0.00315300	0.66	0.5169
AS*BL*CO*SE	2	0.02244271	0.01122136	2.36	0.0989
CU*BL*CO*SE	2	0.01753293	0.00876647	1.85	0.1627
OR*AS*BL*CO*SE	2	0.02234440	0.01117220	2.35	0.0999
OR*CU*BL*CO*SE	2	0.00372887	0.00186444	0.39	0.6763
AS*CU*BL*CO*SE	2	0.00277256	0.00138628	0.29	0.7474
OR*AS*CU*BL*CO*SE	2	0.03967395	0.01983698	4.18	0.0178

TABLE C-4. ANOVA Table for Mean Correct Lift Time in Experiment 2.

Tests of Hypotheses using the Anova MS for SU(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
OR	1	41775.3974	41775.3974	0.12	0.7315
AS	1	601696.3388	601696.3388	1.71	0.1960
CU	1	2227740.4087	2227740.4087	6.34	0.0147
OR*AS	1	384364.3767	384364.3767	1.09	0.3001
OR*CU	1	237360.3045	237360.3045	0.68	0.4146
AS*CU	1	129570.3416	129570.3416	0.37	0.5461
OR*AS*CU	1	334433.9055	334433.9055	0.95	0.3334

Tests of Hypotheses using the Anova MS for SU*RE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE	1	0.68724	0.68724	0.00	0.9954
OR*RE	1	200659.96567	200659.96567	9.63	0.0030
AS*RE	1	3305.02049	3305.02049	0.16	0.6919
CU*RE	1	2846.57925	2846.57925	0.14	0.7130
OR*AS*RE	1	22068.84730	22068.84730	1.06	0.3078
OR*CU*RE	1	40119.32212	40119.32212	1.93	0.1707
AS*CU*RE	1	37534.86888	37534.86888	1.80	0.1849
OR*AS*CU*RE	1	6327.05627	6327.05627	0.30	0.5838

Tests of Hypotheses using the Anova MS for SU*BL(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL	1	95291.146991	95291.146991	6.03	0.0172
OR*BL	1	38.389013	38.389013	0.00	0.9609
AS*BL	1	12703.049292	12703.049292	0.80	0.3737
CU*BL	1	26309.770321	26309.770321	1.67	0.2022
OR*AS*BL	1	5455.551364	5455.551364	0.35	0.5591
OR*CU*BL	1	1093.929282	1093.929282	0.07	0.7934
AS*CU*BL	1	9855.223754	9855.223754	0.62	0.4330
OR*AS*CU*BL	1	7338.280718	7338.280718	0.46	0.4983

Tests of Hypotheses using the Anova MS for SU*CO(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO	1	85034.574594	85034.574594	31.38	0.0001
OR*CO	1	1871.537258	1871.537258	0.69	0.4095
AS*CO	1	14206.382102	14206.382102	5.24	0.0258
CU*CO	1	36752.951285	36752.951285	13.56	0.0005
OR*AS*CO	1	835.615018	835.615018	0.31	0.5809
OR*CU*CO	1	269.729311	269.729311	0.10	0.7535
AS*CU*CO	1	7542.735044	7542.735044	2.78	0.1008
OR*AS*CU*CO	1	6.467757	6.467757	0.00	0.9612

Tests of Hypotheses using the Anova MS for SU*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SE	2	10712.484726	5356.242363	3.38	0.0375
OR*SE	2	2010.518118	1005.259059	0.63	0.5321
AS*SE	2	3584.214557	1792.107278	1.13	0.3263
CU*SE	2	13566.668560	6783.334280	4.28	0.0162
OR*AS*SE	2	6877.200877	3438.600438	2.17	0.1189
OR*CU*SE	2	829.042964	414.521482	0.26	0.7703
AS*CU*SE	2	2947.762919	1473.881459	0.93	0.3975
OR*AS*CU*SE	2	3995.420322	1997.710161	1.26	0.2874

Table continues...

Tests of Hypotheses using the Anova MS for SU*RE*BL(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*BL	1	14920.737428	14920.737428	2.29	0.1361
OR*RE*BL	1	11580.863713	11580.863713	1.77	0.1882
AS*RE*BL	1	763.035091	763.035091	0.12	0.7337
CU*RE*BL	1	11768.654018	11768.654018	1.80	0.1847
OR*AS*RE*BL	1	910.306142	910.306142	0.14	0.7102
OR*CU*RE*BL	1	953.807284	953.807284	0.15	0.7037
AS*CU*RE*BL	1	27947.484643	27947.484643	4.28	0.0431
OR*AS*CU*RE*BL	1	52.230657	52.230657	0.01	0.9290

Tests of Hypotheses using the Anova MS for SU*RE*CO(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*CO	1	889.7479509	889.7479509	0.61	0.4369
OR*RE*CO	1	6386.1058607	6386.1058607	4.40	0.0404
AS*RE*CO	1	13.5110880	13.5110880	0.01	0.9235
CU*RE*CO	1	14.0394346	14.0394346	0.01	0.9220
OR*AS*RE*CO	1	3431.9740462	3431.9740462	2.37	0.1297
OR*CU*RE*CO	1	639.8493856	639.8493856	0.44	0.5094
AS*CU*RE*CO	1	388.4984160	388.4984160	0.27	0.6069
OR*AS*CU*RE*CO	1	2346.0869744	2346.0869744	1.62	0.2088

Tests of Hypotheses using the Anova MS for SU*RE*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*SE	2	1885.4275868	942.7137934	1.20	0.3057
OR*RE*SE	2	1284.8697735	642.4348868	0.82	0.4447
AS*RE*SE	2	1241.7884108	620.8942054	0.79	0.4569
CU*RE*SE	2	640.4324774	320.2162387	0.41	0.6667
OR*AS*RE*SE	2	4882.3023899	2441.1511950	3.10	0.0489
OR*CU*RE*SE	2	1291.2772316	645.6386158	0.82	0.4429
AS*CU*RE*SE	2	16.0869364	8.0434682	0.01	0.9898
OR*AS*CU*RE*SE	2	2355.5883949	1177.7941974	1.50	0.2284

Tests of Hypotheses using the Anova MS for SU*BL*CO(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO	1	2476.1572602	2476.1572602	1.07	0.3058
OR*BL*CO	1	4407.8433367	4407.8433367	1.90	0.1734
AS*BL*CO	1	5848.4875147	5848.4875147	2.52	0.1178
CU*BL*CO	1	612.3340724	612.3340724	0.26	0.6093
OR*AS*BL*CO	1	5.0233599	5.0233599	0.00	0.9630
OR*CU*BL*CO	1	1987.6286862	1987.6286862	0.86	0.3584
AS*CU*BL*CO	1	6047.0222365	6047.0222365	2.61	0.1119
OR*AS*CU*BL*CO	1	266.1097478	266.1097478	0.11	0.7360

Tests of Hypotheses using the Anova MS for SU*BL*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*SE	2	1418.3062467	709.1531233	0.54	0.5814
OR*BL*SE	2	949.9844667	474.9922333	0.37	0.6950
AS*BL*SE	2	3047.2882294	1523.6441147	1.17	0.3139
CU*BL*SE	2	789.2465137	394.6232569	0.30	0.7390
OR*AS*BL*SE	2	2033.6807509	1016.8403754	0.78	0.4602
OR*CU*BL*SE	2	308.6518442	154.3259221	0.12	0.8883
AS*CU*BL*SE	2	345.8785052	172.9392526	0.13	0.8757
OR*AS*CU*BL*SE	2	29.1508710	14.5754355	0.01	0.9889

Table continues...

Tests of Hypotheses using the Anova MS for SU*CO*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO*SE	2	50068.743672	25034.371836	7.04	0.0013
OR*CO*SE	2	298.811409	149.405704	0.04	0.9589
AS*CO*SE	2	19742.050351	9871.025176	2.78	0.0666
CU*CO*SE	2	14154.240349	7077.120174	1.99	0.1415
OR*AS*CO*SE	2	2591.785676	1295.892838	0.36	0.6954
OR*CU*CO*SE	2	3137.529409	1568.764704	0.44	0.6444
AS*CU*CO*SE	2	8764.423715	4382.211857	1.23	0.2955
OR*AS*CU*CO*SE	2	1871.296868	935.648434	0.26	0.7691

Tests of Hypotheses using the Anova MS for SU*RE*BL*CO(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*BL*CO	1	66.2155465	66.2155465	0.04	0.8498
OR*RE*BL*CO	1	234.7276263	234.7276263	0.13	0.7216
AS*RE*BL*CO	1	22.1498977	22.1498977	0.01	0.9128
CU*RE*BL*CO	1	1446.9755533	1446.9755533	0.79	0.3777
OR*AS*RE*BL*CO	1	4520.4145502	4520.4145502	2.47	0.1216
OR*CU*RE*BL*CO	1	1480.7418417	1480.7418417	0.81	0.3722
AS*CU*RE*BL*CO	1	1956.9760447	1956.9760447	1.07	0.3055
OR*AS*CU*RE*BL*CO	1	2993.5385736	2993.5385736	1.64	0.2062

Tests of Hypotheses using the Anova MS for SU*RE*BL*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*BL*SE	2	3336.9645783	1668.4822892	3.23	0.0435
OR*RE*BL*SE	2	1517.2252059	758.6126029	1.47	0.2351
AS*RE*BL*SE	2	593.9673414	296.9836707	0.57	0.5649
CU*RE*BL*SE	2	852.2887862	426.1443931	0.82	0.4414
OR*AS*RE*BL*SE	2	425.5221919	212.7610960	0.41	0.6638
OR*CU*RE*BL*SE	2	1021.7028200	510.8514100	0.99	0.3757
AS*CU*RE*BL*SE	2	4676.4617340	2338.2308670	4.52	0.0129
OR*AS*CU*RE*BL*SE	2	2.7449394	1.3724697	0.00	0.9974

Tests of Hypotheses using the Anova MS for SU*RE*CO*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*CO*SE	2	1697.2192426	848.6096213	0.71	0.4936
OR*RE*CO*SE	2	3001.5893411	1500.7946705	1.26	0.2886
AS*RE*CO*SE	2	2637.6775196	1318.8387598	1.10	0.3351
CU*RE*CO*SE	2	494.6423035	247.3211518	0.21	0.8133
OR*AS*RE*CO*SE	2	1488.3497984	744.1748992	0.62	0.5381
OR*CU*RE*CO*SE	2	2187.1011463	1093.5505731	0.92	0.4033
AS*CU*RE*CO*SE	2	60.1636955	30.0818478	0.03	0.9751
OR*AS*CU*RE*CO*SE	2	3348.4346339	1674.2173169	1.40	0.2505

Tests of Hypotheses using the Anova MS for SU*BL*CO*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO*SE	2	756.9524564	378.4762282	0.27	0.7645
OR*BL*CO*SE	2	2832.6018588	1416.3009294	1.01	0.3685
AS*BL*CO*SE	2	3602.2972954	1801.1486477	1.28	0.2818
CU*BL*CO*SE	2	2466.1163606	1233.0581803	0.88	0.4188
OR*AS*BL*CO*SE	2	275.9439346	137.9719673	0.10	0.9066
OR*CU*BL*CO*SE	2	3007.1904203	1503.5952101	1.07	0.3467
AS*CU*BL*CO*SE	2	6190.4126775	3095.2063387	2.20	0.1154
OR*AS*CU*BL*CO*SE	2	2002.0329976	1001.0164988	0.71	0.4929

TABLE C-5. ANOVA Table for Mean Correct Movement Time in Experiment 2.

Tests of Hypotheses using the Anova MS for SU(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
OR	1	274446.8931	274446.8931	0.63	0.4306
AS	1	3880414.4711	3880414.4711	8.91	0.0042
CU	1	2448651.8742	2448651.8742	5.62	0.0212
OR*AS	1	225670.4369	225670.4369	0.52	0.4746
OR*CU	1	11490.0767	11490.0767	0.03	0.8715
AS*CU	1	862961.1958	862961.1958	1.98	0.1647
OR*AS*CU	1	675944.4072	675944.4072	1.55	0.2180

Tests of Hypotheses using the Anova MS for SU*RE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE	1	1314241.2464	1314241.2464	45.54	0.0001
OR*RE	1	146719.8444	146719.8444	5.08	0.0281
AS*RE	1	121538.8785	121538.8785	4.21	0.0448
CU*RE	1	68838.6906	68838.6906	2.39	0.1281
OR*AS*RE	1	373906.6141	373906.6141	12.96	0.0007
OR*CU*RE	1	194580.3900	194580.3900	6.74	0.0120
AS*CU*RE	1	219.0485	219.0485	0.01	0.9309
OR*AS*CU*RE	1	6645.4253	6645.4253	0.23	0.6332

Tests of Hypotheses using the Anova MS for SU*BL(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL	1	9057.428551	9057.428551	0.57	0.4538
OR*BL	1	1833.803076	1833.803076	0.12	0.7356
AS*BL	1	5390.419432	5390.419432	0.34	0.5630
CU*BL	1	12309.144981	12309.144981	0.77	0.3830
OR*AS*BL	1	11689.109715	11689.109715	0.73	0.3952
OR*CU*BL	1	7037.724333	7037.724333	0.44	0.5088
AS*CU*BL	1	24430.194681	24430.194681	1.53	0.2206
OR*AS*CU*BL	1	9871.759608	9871.759608	0.62	0.4343

Tests of Hypotheses using the Anova MS for SU*CO(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO	1	841262.94035	841262.94035	30.33	0.0001
OR*CO	1	45931.01151	45931.01151	1.66	0.2034
AS*CO	1	4322.07689	4322.07689	0.16	0.6945
CU*CO	1	136883.18117	136883.18117	4.94	0.0304
OR*AS*CO	1	25144.55559	25144.55559	0.91	0.3451
AS*CU*CO	1	7288.74448	7288.74448	0.26	0.6102
OR*AS*CU*CO	1	294.10105	294.10105	0.01	0.9183

Tests of Hypotheses using the Anova MS for SU*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SE	2	272657.1888	136328.5944	14.90	0.0001
OR*SE	2	31375.7565	15687.8782	1.72	0.1847
AS*SE	2	38432.3900	19216.1950	2.10	0.1272
CU*SE	2	1159592.2340	579796.1170	63.38	0.0001
OR*AS*SE	2	23714.4674	11857.2337	1.30	0.2776
OR*CU*SE	2	48978.7817	24489.3909	2.68	0.0732
AS*CU*SE	2	18963.1452	9481.5726	1.04	0.3581
OR*AS*CU*SE	2	80191.0128	40095.5064	4.38	0.0147

Table continues...

ANOVA on Movement Time in Experiment 2

Tests of Hypotheses using the Anova MS for SU*RE*BL(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*BL	1	21544.776413	21544.776413	1.33	0.2531
OR*RE*BL	1	36923.757243	36923.757243	2.29	0.1362
AS*RE*BL	1	19217.724408	19217.724408	1.19	0.2801
CU*RE*BL	1	4315.566561	4315.566561	0.27	0.6073
OR*AS*RE*BL	1	8541.218958	8541.218958	0.53	0.4702
OR*CU*RE*BL	1	1128.048343	1128.048343	0.07	0.7926
AS*CU*RE*BL	1	17138.331689	17138.331689	1.06	0.3074
OR*AS*CU*RE*BL	1	36563.843851	36563.843851	2.26	0.1381

Tests of Hypotheses using the Anova MS for SU*RE*CO(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*CO	1	16.216948	16.216948	0.00	0.9605
OR*RE*CO	1	13594.708750	13594.708750	2.07	0.1553
AS*RE*CO	1	4639.791450	4639.791450	0.71	0.4036
CU*RE*CO	1	14546.948292	14546.948292	2.22	0.1418
OR*AS*RE*CO	1	11141.895482	11141.895482	1.70	0.1975
OR*CU*RE*CO	1	9147.170150	9147.170150	1.40	0.2424
AS*CU*RE*CO	1	754.660799	754.660799	0.12	0.7356
OR*AS*CU*RE*CO	1	1331.289243	1331.289243	0.20	0.6539

Tests of Hypotheses using the Anova MS for SU*RE*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*SE	2	25492.059592	12746.029796	2.62	0.0774
OR*RE*SE	2	7532.847834	3766.423917	0.77	0.4638
AS*RE*SE	2	5708.643046	2854.321523	0.59	0.5581
CU*RE*SE	2	7073.522749	3536.761374	0.73	0.4859
OR*AS*RE*SE	2	3649.754862	1824.877431	0.37	0.6883
OR*CU*RE*SE	2	17636.557056	8818.278528	1.81	0.1682
AS*CU*RE*SE	2	22070.555486	11035.277743	2.27	0.1084
OR*AS*CU*RE*SE	2	4373.258390	2186.629195	0.45	0.6393

Tests of Hypotheses using the Anova MS for SU*BL*CO(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO	1	8781.230701	8781.230701	1.65	0.2040
OR*BL*CO	1	21819.809363	21819.809363	4.10	0.0475
AS*BL*CO	1	303.408465	303.408465	0.06	0.8121
CU*BL*CO	1	60.018321	60.018321	0.01	0.9158
OR*AS*BL*CO	1	178.825674	178.825674	0.03	0.8551
OR*CU*BL*CO	1	2333.844233	2333.844233	0.44	0.5103
AS*CU*BL*CO	1	1991.393423	1991.393423	0.37	0.5430
OR*AS*CU*BL*CO	1	14097.667364	14097.667364	2.65	0.1090

Tests of Hypotheses using the Anova MS for SU*BL*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*SE	2	3926.485071	1963.242536	0.43	0.6497
OR*BL*SE	2	8852.351053	4426.175526	0.98	0.3800
AS*BL*SE	2	764.465946	382.232973	0.08	0.9192
CU*BL*SE	2	5337.380942	2668.690471	0.59	0.5569
OR*AS*BL*SE	2	595.917798	297.958899	0.07	0.9364
OR*CU*BL*SE	2	14411.923323	7205.961661	1.59	0.2087
AS*CU*BL*SE	2	5379.166157	2689.583079	0.59	0.5543
OR*AS*CU*BL*SE	2	1597.834218	798.917109	0.18	0.8387

Table continues...

Tests of Hypotheses using the Anova MS for SU*CO*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO*SE	2	283345.32987	141672.66493	10.77	0.0001
OR*CO*SE	2	2253.55678	1126.77839	0.09	0.9180
AS*CO*SE	2	52003.84410	26001.92205	1.98	0.1434
CU*CO*SE	2	689968.64664	344984.32332	26.22	0.0001
OR*AS*CO*SE	2	1693.03685	846.51842	0.06	0.9377
OR*CU*CO*SE	2	3015.60781	1507.80391	0.11	0.8918
AS*CU*CO*SE	2	20686.48098	10343.24049	0.79	0.4581
OR*AS*CU*CO*SE	2	26394.11429	13197.05714	1.00	0.3700

Tests of Hypotheses using the Anova MS for SU*RE*BL*CO(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*BL*CO	1	2702.1057630	2702.1057630	0.67	0.4181
OR*RE*BL*CO	1	6495.2417250	6495.2417250	1.60	0.2112
AS*RE*BL*CO	1	70.9528411	70.9528411	0.02	0.8953
CU*RE*BL*CO	1	1346.3989818	1346.3989818	0.33	0.5670
OR*AS*RE*BL*CO	1	125.2016560	125.2016560	0.03	0.8612
OR*CU*RE*BL*CO	1	310.3500256	310.3500256	0.08	0.7832
AS*CU*RE*BL*CO	1	8525.0380063	8525.0380063	2.10	0.1529
OR*AS*CU*RE*BL*CO	1	2337.6376444	2337.6376444	0.58	0.4511

Tests of Hypotheses using the Anova MS for SU*RE*BL*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*BL*SE	2	15784.110298	7892.055149	1.65	0.1958
OR*RE*BL*SE	2	15384.114339	7692.057169	1.61	0.2039
AS*RE*BL*SE	2	5375.901332	2687.950666	0.56	0.5708
CU*RE*BL*SE	2	49207.309942	24603.654971	5.16	0.0072
OR*AS*RE*BL*SE	2	22169.750942	11084.875471	2.32	0.1026
OR*CU*RE*BL*SE	2	10030.062946	5015.031473	1.05	0.3528
AS*CU*RE*BL*SE	2	17518.185112	8759.092556	1.84	0.1641
OR*AS*CU*RE*BL*SE	2	4694.557393	2347.278696	0.49	0.6126

Tests of Hypotheses using the Anova MS for SU*RE*CO*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
RE*CO*SE	2	15987.129640	7993.564820	1.61	0.2041
OR*RE*CO*SE	2	2970.017594	1485.008797	0.30	0.7418
AS*RE*CO*SE	2	5905.994559	2952.997279	0.60	0.5531
CU*RE*CO*SE	2	3082.595943	1541.297972	0.31	0.7335
OR*AS*RE*CO*SE	2	1179.058710	589.529355	0.12	0.8880
OR*CU*RE*CO*SE	2	2110.003529	1055.001764	0.21	0.8087
AS*CU*RE*CO*SE	2	347.717967	173.858983	0.04	0.9656
OR*AS*CU*RE*CO*SE	2	23028.107094	11514.053547	2.32	0.1028

Tests of Hypotheses using the Anova MS for SU*BL*CO*SE(OR*AS*CU) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO*SE	2	5752.531987	2876.265993	0.57	0.5661
OR*BL*CO*SE	2	12210.560157	6105.280079	1.21	0.3009
AS*BL*CO*SE	2	6476.942288	3238.471144	0.64	0.5271
CU*BL*CO*SE	2	924.039167	462.019583	0.09	0.9123
OR*AS*BL*CO*SE	2	3565.709573	1782.854787	0.35	0.7023
OR*CU*BL*CO*SE	2	22148.669660	11074.334830	2.20	0.1153
AS*CU*BL*CO*SE	2	4554.871715	2277.435858	0.45	0.6369
OR*AS*CU*BL*CO*SE	2	9264.552725	4632.276363	0.92	0.4010

APPENDIX D: ANOVA Tables for the First Session in Experiment 2

TABLE D-1. Factor name abbreviations for the First Session in Experiment 2.

Factor Name	Abbreviation
Assignment	AS
Cue Dimension	CU
Response Type	RE
Block	BL
Congruency	CO
Separation	SE
Subject	SU

TABLE D-2. ANOVA Table for Mean Correct Total Reaction Time for the First Session in Experiment 2.

Tests of Hypotheses using the Anova MS for SU(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
AS	1	1373005.2061	1373005.2061	2.99	0.0892
CU	1	6840521.2587	6840521.2587	14.91	0.0003
RE	1	1755641.3796	1755641.3796	3.83	0.0555
AS*CU	1	163006.1825	163006.1825	0.36	0.5536
AS*RE	1	323114.8543	323114.8543	0.70	0.4050
CU*RE	1	173473.7746	173473.7746	0.38	0.5412
AS*CU*RE	1	623.6210	623.6210	0.00	0.9707

Tests of Hypotheses using the Anova MS for SU*BL(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL	1	247549.79888	247549.79888	7.16	0.0098
AS*BL	1	263.56028	263.56028	0.01	0.9307
CU*BL	1	38047.19449	38047.19449	1.10	0.2987
RE*BL	1	2712.14160	2712.14160	0.08	0.7805
AS*CU*BL	1	103066.58893	103066.58893	2.98	0.0898
AS*RE*BL	1	2945.31468	2945.31468	0.09	0.7715
CU*RE*BL	1	32.20905	32.20905	0.00	0.9758
AS*CU*RE*BL	1	254.67079	254.67079	0.01	0.9319

Tests of Hypotheses using the Anova MS for SU*CO(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO	1	987462.45813	987462.45813	46.36	0.0001
AS*CO	1	9516.60609	9516.60609	0.45	0.5066
CU*CO	1	232987.72673	232987.72673	10.94	0.0016
RE*CO	1	26859.79443	26859.79443	1.26	0.2663
AS*CU*CO	1	90.10675	90.10675	0.00	0.9484
AS*RE*CO	1	56249.64586	56249.64586	2.64	0.1098
CU*RE*CO	1	42590.42755	42590.42755	2.00	0.1629
AS*CU*RE*CO	1	530.57368	530.57368	0.02	0.8752

Tests of Hypotheses using the Anova MS for SU*SE(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SE	2	137255.99930	68627.99965	7.60	0.0008
AS*SE	2	13267.29716	6633.64858	0.73	0.4819
CU*SE	2	801719.10796	400859.55398	44.40	0.0001
RE*SE	2	4343.45384	2171.72692	0.24	0.7866
AS*CU*SE	2	5091.31539	2545.65770	0.28	0.7548
AS*RE*SE	2	10296.65583	5148.32792	0.57	0.5670
CU*RE*SE	2	43464.94299	21732.47150	2.41	0.0947
AS*CU*RE*SE	2	12727.83887	6363.91944	0.70	0.4963

Tests of Hypotheses using the Anova MS for SU*BL*CO(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO	1	28652.136258	28652.136258	3.11	0.0835
AS*BL*CO	1	11240.807233	11240.807233	1.22	0.2744
CU*BL*CO	1	1423.441428	1423.441428	0.15	0.6959
RE*BL*CO	1	7833.538751	7833.538751	0.85	0.3607
AS*CU*BL*CO	1	8288.506579	8288.506579	0.90	0.3473
AS*RE*BL*CO	1	294.298186	294.298186	0.03	0.8589
CU*RE*BL*CO	1	4440.450149	4440.450149	0.48	0.4907
AS*CU*RE*BL*CO	1	11327.252877	11327.252877	1.23	0.2726

Table continues...

ANOVA for Total RT, First Session of Experiment 2

Tests of Hypotheses using the Anova MS for SU*BL*SE(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*SE	2	29630.411988	14815.205994	2.41	0.0942
AS*BL*SE	2	4718.069098	2359.034549	0.38	0.6819
CU*BL*SE	2	1759.596066	879.798033	0.14	0.8667
RE*BL*SE	2	2944.289784	1472.144892	0.24	0.7872
AS*CU*BL*SE	2	7188.822468	3594.411234	0.59	0.5586
AS*RE*BL*SE	2	1568.705012	784.352506	0.13	0.8802
CU*RE*BL*SE	2	10235.629979	5117.814990	0.83	0.4372
AS*CU*RE*BL*SE	2	6319.599210	3159.799605	0.51	0.5991

Tests of Hypotheses using the Anova MS for SU*CO*SE(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO*SE	2	260184.34583	130092.17291	11.30	0.0001
AS*CO*SE	2	4059.94516	2029.97258	0.18	0.8386
CU*CO*SE	2	485160.62259	242580.31130	21.07	0.0001
RE*CO*SE	2	273.32179	136.66090	0.01	0.9882
AS*CU*CO*SE	2	5401.88687	2700.94343	0.23	0.7913
AS*RE*CO*SE	2	10520.12571	5260.06286	0.46	0.6344
CU*RE*CO*SE	2	1795.92752	897.96376	0.08	0.9250
AS*CU*RE*CO*SE	2	25591.73184	12795.86592	1.11	0.3326

Tests of Hypotheses using the Anova MS for S*BL*CO*SE(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO*SE	2	7938.884639	3969.442320	0.50	0.6101
AS*BL*CO*SE	2	30348.861829	15174.430914	1.90	0.1548
CU*BL*CO*SE	2	2820.087528	1410.043764	0.18	0.8386
RE*BL*CO*SE	2	20736.441869	10368.220934	1.30	0.2776
AS*CU*BL*CO*SE	2	16108.985772	8054.492886	1.01	0.3686
AS*RE*BL*CO*SE	2	10804.947022	5402.473511	0.68	0.5110
CU*RE*BL*CO*SE	2	6945.808159	3472.904079	0.43	0.6489
AS*CU*RE*BL*CO*SE	2	11896.687656	5948.343828	0.74	0.4777

TABLE D-3. ANOVA Table for Accuracy for the First Session in Experiment 2.

Tests of Hypotheses using the Anova MS for SU(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
AS	1	0.11398603	0.11398603	1.67	0.2019
CU	1	0.15310516	0.15310516	2.24	0.1401
RE	1	0.01005268	0.01005268	0.15	0.7028
AS*CU	1	0.07257716	0.07257716	1.06	0.3072
AS*RE	1	0.10649430	0.10649430	1.56	0.2172
CU*RE	1	0.00722966	0.00722966	0.11	0.7462
AS*CU*RE	1	0.27505319	0.27505319	4.02	0.0497

Tests of Hypotheses using the Anova MS for SU*BL(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL	1	0.05778773	0.05778773	8.89	0.0042
AS*BL	1	0.00992103	0.00992103	1.53	0.2218
CU*BL	1	0.02707877	0.02707877	4.17	0.0459
RE*BL	1	0.00393356	0.00393356	0.61	0.4398
AS*CU*BL	1	0.00019054	0.00019054	0.03	0.8647
AS*RE*BL	1	0.00075271	0.00075271	0.12	0.7349
CU*RE*BL	1	0.00240946	0.00240946	0.37	0.5450
AS*CU*RE*BL	1	0.00022692	0.00022692	0.03	0.8524

Tests of Hypotheses using the Anova MS for SU*CO(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO	1	0.66533237	0.66533237	21.48	0.0001
AS*CO	1	0.02603343	0.02603343	0.84	0.3632
CU*CO	1	0.12549808	0.12549808	4.05	0.0489
RE*CO	1	0.00256947	0.00256947	0.08	0.7744
AS*CU*CO	1	0.00073397	0.00073397	0.02	0.8782
AS*RE*CO	1	0.05214950	0.05214950	1.68	0.1998
CU*RE*CO	1	0.01520708	0.01520708	0.49	0.4864
AS*CU*RE*CO	1	0.05415659	0.05415659	1.75	0.1914

Tests of Hypotheses using the Anova MS for SU*SE(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SE	2	0.22925509	0.11462754	22.04	0.0001
AS*SE	2	0.00320589	0.00160295	0.31	0.7354
CU*SE	2	0.81785426	0.40892713	78.63	0.0001
RE*SE	2	0.01485343	0.00742671	1.43	0.2441
AS*CU*SE	2	0.09184387	0.04592194	8.83	0.0003
AS*RE*SE	2	0.00445816	0.00222908	0.43	0.6525
CU*RE*SE	2	0.01872790	0.00936395	1.80	0.1700
AS*CU*RE*SE	2	0.00209168	0.00104584	0.20	0.8181

Tests of Hypotheses using the Anova MS for SU*BL*CO(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO	1	0.00102697	0.00102697	0.21	0.6449
AS*BL*CO	1	0.01730177	0.01730177	3.62	0.0624
CU*BL*CO	1	0.00028260	0.00028260	0.06	0.8089
RE*BL*CO	1	0.01407757	0.01407757	2.94	0.0918
AS*CU*BL*CO	1	0.00305817	0.00305817	0.64	0.4274
AS*RE*BL*CO	1	0.00173630	0.00173630	0.36	0.5493
CU*RE*BL*CO	1	0.00306451	0.00306451	0.64	0.4269
AS*CU*RE*BL*CO	1	0.01070616	0.01070616	2.24	0.1403

Table continues...

ANOVA for Accuracy, First Session of Experiment 2

Tests of Hypotheses using the Anova MS for SU*BL*SE(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*SE	2	0.02146651	0.01073326	1.83	0.1654
AS*BL*SE	2	0.00758621	0.00379311	0.65	0.5260
CU*BL*SE	2	0.00572844	0.00286422	0.49	0.6152
RE*BL*SE	2	0.01752740	0.00876370	1.49	0.2292
AS*CU*BL*SE	2	0.01990695	0.00995348	1.70	0.1882
AS*RE*BL*SE	2	0.00480699	0.00240349	0.41	0.6650
CU*RE*BL*SE	2	0.00694723	0.00347361	0.59	0.5551
AS*CU*RE*BL*SE	2	0.00014773	0.00007387	0.01	0.9875

Tests of Hypotheses using the Anova MS for SU*CO*SE(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO*SE	2	0.13234862	0.06617431	5.16	0.0072
AS*CO*SE	2	0.02426620	0.01213310	0.95	0.3915
CU*CO*SE	2	0.49911124	0.24955562	19.45	0.0001
RE*CO*SE	2	0.01758734	0.00879367	0.69	0.5060
AS*CU*CO*SE	2	0.03938543	0.01969272	1.53	0.2200
AS*RE*CO*SE	2	0.00971077	0.00485538	0.38	0.6858
CU*RE*CO*SE	2	0.00242369	0.00121185	0.09	0.9100
AS*CU*RE*CO*SE	2	0.01113456	0.00556728	0.43	0.6491

Tests of Hypotheses using the Anova MS for S*BL*CO*SE(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO*SE	2	0.03954720	0.01977360	2.92	0.0583
AS*BL*CO*SE	2	0.01787695	0.00893847	1.32	0.2719
CU*BL*CO*SE	2	0.01296545	0.00648273	0.96	0.3877
RE*BL*CO*SE	2	0.00849251	0.00424626	0.63	0.5366
AS*CU*BL*CO*SE	2	0.01421118	0.00710559	1.05	0.3542
AS*RE*BL*CO*SE	2	0.03149736	0.01574868	2.32	0.1028
CU*RE*BL*CO*SE	2	0.00819879	0.00409940	0.60	0.5482
AS*CU*RE*BL*CO*SE	2	0.02136665	0.01068332	1.57	0.2116

TABLE D-4. ANOVA Table for Mean Correct Lift Time for the First Session in Experiment 2.

Tests of Hypotheses using the Anova MS for SU(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
AS	1	427116.0284	427116.0284	1.83	0.1818
CU	1	1432887.1116	1432887.1116	6.13	0.0163
RE	1	20718.6025	20718.6025	0.09	0.7670
AS*CU	1	96580.8285	96580.8285	0.41	0.5229
AS*RE	1	229476.4177	229476.4177	0.98	0.3259
CU*RE	1	94109.8866	94109.8866	0.40	0.5282
AS*CU*RE	1	298024.2586	298024.2586	1.28	0.2635

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL	1	86655.785401	86655.785401	4.93	0.0305
AS*BL	1	10207.216465	10207.216465	0.58	0.4493
CU*BL	1	8622.352651	8622.352651	0.49	0.4867
RE*BL	1	6722.732744	6722.732744	0.38	0.5389
AS*CU*BL	1	5671.184401	5671.184401	0.32	0.5724
AS*RE*BL	1	1069.004735	1069.004735	0.06	0.8062
CU*RE*BL	1	10019.337812	10019.337812	0.57	0.4535
AS*CU*RE*BL	1	31963.723703	31963.723703	1.82	0.1830

Tests of Hypotheses using the Anova MS for SU*CO(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO	1	69013.554497	69013.554497	20.07	0.0001
AS*CO	1	15801.723072	15801.723072	4.59	0.0364
CU*CO	1	23545.766608	23545.766608	6.85	0.0114
RE*CO	1	90.217697	90.217697	0.03	0.8719
AS*CU*CO	1	9151.061988	9151.061988	2.66	0.1085
AS*RE*CO	1	530.817788	530.817788	0.15	0.6959
CU*RE*CO	1	80.347009	80.347009	0.02	0.8791
AS*CU*RE*CO	1	247.610052	247.610052	0.07	0.7894

Tests of Hypotheses using the Anova MS for SU*SE(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SE	2	5041.9521092	2520.9760546	2.55	0.0827
AS*SE	2	416.9447528	208.4723764	0.21	0.8103
CU*SE	2	5491.4208286	2745.7104143	2.78	0.0666
RE*SE	2	846.0386402	423.0193201	0.43	0.6531
AS*CU*SE	2	3239.6297763	1619.8148881	1.64	0.1991
AS*RE*SE	2	6980.2192158	3490.1096079	3.53	0.0327
CU*RE*SE	2	460.3772655	230.1886328	0.23	0.7928
AS*CU*RE*SE	2	1767.4388472	883.7194236	0.89	0.4122

Tests of Hypotheses using the Anova MS for SU*BL*CO(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO	1	2117.821949	2117.821949	0.55	0.4624
AS*BL*CO	1	10326.200548	10326.200548	2.67	0.1078
CU*BL*CO	1	1998.750479	1998.750479	0.52	0.4752
RE*BL*CO	1	2777.277312	2777.277312	0.72	0.4003
AS*CU*BL*CO	1	8774.924256	8774.924256	2.27	0.1376
AS*RE*BL*CO	1	3.038316	3.038316	0.00	0.9777
CU*RE*BL*CO	1	3413.194247	3413.194247	0.88	0.3515
AS*CU*RE*BL*CO	1	1833.187134	1833.187134	0.47	0.4940

Table continues...

ANOVA for Lift Time, First Session of Experiment 2

Tests of Hypotheses using the Anova MS for SU*BL*SE(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*SE	2	1995.5920804	997.7960402	0.94	0.3949
AS*BL*SE	2	2336.9768113	1168.4884057	1.10	0.3374
CU*BL*SE	2	1412.2919254	706.1459627	0.66	0.5173
RE*BL*SE	2	468.4787130	234.2393565	0.22	0.8029
AS*CU*BL*SE	2	203.5758038	101.7879019	0.10	0.9089
AS*RE*BL*SE	2	362.7279283	181.3639642	0.17	0.8437
CU*RE*BL*SE	2	90.8012810	45.4006405	0.04	0.9583
AS*CU*RE*BL*SE	2	2105.7281044	1052.8640522	0.99	0.3754

Tests of Hypotheses using the Anova MS for SU*CO*SE(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO*SE	2	18361.596511	9180.798256	2.67	0.0735
AS*CO*SE	2	14780.679044	7390.339522	2.15	0.1212
CU*CO*SE	2	9185.206725	4592.603362	1.34	0.2669
RE*CO*SE	2	1558.843426	779.421713	0.23	0.7974
AS*CU*CO*SE	2	7160.470279	3580.235140	1.04	0.3561
AS*RE*CO*SE	2	3169.462194	1584.731097	0.46	0.6317
CU*RE*CO*SE	2	2350.809656	1175.404828	0.34	0.7110
AS*CU*RE*CO*SE	2	1230.704296	615.352148	0.18	0.8363

Tests of Hypotheses using the Anova MS for S*BL*CO*SE(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO*SE	2	1038.5901259	519.2950629	0.25	0.7794
AS*BL*CO*SE	2	7495.5533193	3747.7766597	1.80	0.1697
CU*BL*CO*SE	2	2528.1299595	1264.0649797	0.61	0.5463
RE*BL*CO*SE	2	5827.5684526	2913.7842263	1.40	0.2506
AS*CU*BL*CO*SE	2	8846.2322397	4423.1161199	2.13	0.1240
AS*RE*BL*CO*SE	2	1862.1073983	931.0536992	0.45	0.6402
CU*RE*BL*CO*SE	2	8353.0170616	4176.5085308	2.01	0.1390
AS*CU*RE*BL*CO*SE	2	2646.0798946	1323.0399473	0.64	0.5312

TABLE D-5. ANOVA Table for Mean Correct Movement Time for the First Session in Experiment 2.

Tests of Hypotheses using the Anova MS for SU(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
AS	1	3331698.8925	3331698.8925	12.02	0.0010
CU	1	2011876.6893	2011876.6893	7.26	0.0093
RE	1	1394918.3174	1394918.3174	5.03	0.0289
AS*CU	1	510531.4045	510531.4045	1.84	0.1802
AS*RE	1	7991.4583	7991.4583	0.03	0.8658
CU*RE	1	12040.3400	12040.3400	0.04	0.8357
AS*CU*RE	1	325913.5483	325913.5483	1.18	0.2829

Tests of Hypotheses using the Anova MS for SU*BL(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL	1	41278.137649	41278.137649	1.86	0.1779
AS*BL	1	13751.152837	13751.152837	0.62	0.4343
CU*BL	1	10444.896515	10444.896515	0.47	0.4953
RE*BL	1	17974.898488	17974.898488	0.81	0.3717
AS*CU*BL	1	60384.505337	60384.505337	2.72	0.1045
AS*RE*BL	1	465.485614	465.485614	0.02	0.8853
CU*RE*BL	1	11187.704129	11187.704129	0.50	0.4804
AS*CU*RE*BL	1	26512.177942	26512.177942	1.20	0.2788

Tests of Hypotheses using the Anova MS for SU*CO(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO	1	534371.44775	534371.44775	29.19	0.0001
AS*CO	1	792.52447	792.52447	0.04	0.8359
CU*CO	1	108400.11241	108400.11241	5.92	0.0182
RE*CO	1	23836.66742	23836.66742	1.30	0.2587
AS*CU*CO	1	7425.04931	7425.04931	0.41	0.5268
AS*RE*CO	1	45851.91158	45851.91158	2.50	0.1192
CU*RE*CO	1	38971.03756	38971.03756	2.13	0.1502
AS*CU*RE*CO	1	53.26891	53.26891	0.00	0.9572

Tests of Hypotheses using the Anova MS for SU*SE(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SE	2	102447.03893	51223.51946	6.92	0.0015
AS*SE	2	9677.05460	4838.52730	0.65	0.5220
CU*SE	2	703714.38228	351857.19114	47.55	0.0001
RE*SE	2	6985.58515	3492.79258	0.47	0.6249
AS*CU*SE	2	3097.91598	1548.95799	0.21	0.8114
AS*RE*SE	2	12100.80074	6050.40037	0.82	0.4440
CU*RE*SE	2	43442.83540	21721.41770	2.94	0.0572
AS*CU*RE*SE	2	22475.73363	11237.86682	1.52	0.2234

Tests of Hypotheses using the Anova MS for SU*BL*CO(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO	1	15190.468733	15190.468733	2.86	0.0966
AS*BL*CO	1	19.401900	19.401900	0.00	0.9521
CU*BL*CO	1	48.704551	48.704551	0.01	0.9241
RE*BL*CO	1	19939.462146	19939.462146	3.75	0.0579
AS*CU*BL*CO	1	6.934427	6.934427	0.00	0.9713
AS*RE*BL*CO	1	237.531121	237.531121	0.04	0.8334
CU*RE*BL*CO	1	67.472319	67.472319	0.01	0.9107
AS*CU*RE*BL*CO	1	22274.160268	22274.160268	4.19	0.0454

Table continues...

ANOVA for Movement Time, First Session of Experiment 2

Tests of Hypotheses using the Anova MS for SU*BL*SE(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*SE	2	16723.844323	8361.922161	1.80	0.1701
AS*BL*SE	2	13620.484361	6810.242181	1.47	0.2353
CU*BL*SE	2	2526.046157	1263.023079	0.27	0.7625
RE*BL*SE	2	1479.516835	739.758417	0.16	0.8530
AS*CU*BL*SE	2	7464.188276	3732.094138	0.80	0.4504
AS*RE*BL*SE	2	3431.923028	1715.961514	0.37	0.6920
CU*RE*BL*SE	2	8424.826369	4212.413184	0.91	0.4068
AS*CU*RE*BL*SE	2	8362.534537	4181.267268	0.90	0.4095

Tests of Hypotheses using the Anova MS for SU*CO*SE(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
CO*SE	2	145856.71086	72928.35543	8.19	0.0005
AS*CO*SE	2	27975.97074	13987.98537	1.57	0.2124
CU*CO*SE	2	368328.28289	184164.14144	20.68	0.0001
RE*CO*SE	2	3118.08252	1559.04126	0.18	0.8396
AS*CU*CO*SE	2	24736.59039	12368.29519	1.39	0.2536
AS*RE*CO*SE	2	4378.42979	2189.21490	0.25	0.7825
CU*RE*CO*SE	2	4955.54220	2477.77110	0.28	0.7576
AS*CU*RE*CO*SE	2	15655.51961	7827.75981	0.88	0.4181

Tests of Hypotheses using the Anova MS for S*BL*CO*SE(AS*CU*RE) as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
BL*CO*SE	2	13859.195748	6929.597874	1.15	0.3200
AS*BL*CO*SE	2	7712.353596	3856.176798	0.64	0.5289
CU*BL*CO*SE	2	10666.149025	5333.074513	0.89	0.4152
RE*BL*CO*SE	2	6870.438795	3435.219398	0.57	0.5668
AS*CU*BL*CO*SE	2	1485.326445	742.663222	0.12	0.8841
AS*RE*BL*CO*SE	2	11196.267891	5598.133945	0.93	0.3976
CU*RE*BL*CO*SE	2	5972.793066	2986.396533	0.50	0.6102
AS*CU*RE*BL*CO*SE	2	5796.644897	2898.322448	0.48	0.6192