C.Ü. Sosyal Bilimler Dergisi Mayıs 2005 Cilt : 29 No:2 139-147

REACTION TIME AS A MEASURE OF EFFECTS OF AUDITORY STIMULI ON VISION

Aslı Aslan

Öz

Bu çalışma birbirlerinden farklı sesli uyarıcıların görsel bir hedefin yerini hiçbir sesli uyarıcının olmadığı durumdakine göre daha çabuk bulmaya yardımcı olup olmadıklarını bulmak amacını güdüyordu. Çalışma Deney 1 ve Deney 2 diye adlandırılan iki deneyden ibaretti. Deneklerin görevi bilgisayar ekranında düğmelerden biri üzerinde görünecek olan ve görsel hedef işlevi yapan A harfini bulmaktı. Deney 1'in denekleri hedef harfi bulmalarına yardımcı olabilecek herhangi bir sesli ipucu işitmediler fakat hedef harf diğer renksiz düğmeli harflerin aksine kırmızı düğme içinde belirdi. Deney 1 de deneklerin reaksiyon süreleri A harfinin renksiz gözüktüğündeki duruma kıyasla renkli düğme içinde gözüktüğünde daha hızlıydı. Deney 2'de denekler düğmeler dairesini görmeden hemen önce kısa bir melodi veya bir nota işittiler. Kısa melodinin Deney 2 deneklerinin ortalama tepki süresini kısalttığı bulundu. Tek notanın Deney 2 deneklerinin tepki sürelerini kısalttığını gösterecek deliller gözlenmedi.

Anahtar Sözcükler

Duyusal Uyarıcı, Görsel Tarama Testi, Kolaylaştırma

Sesli Uyarımların Görme Üzerindeki Etkilerini İncelemek İçin Bir Ölçüt Olarak Reaksiyon Süresi

Abstract

This study was intended to determine whether an auditory stimulus would help to locate a visual target faster than it could be located without any auditory stimulus. The study consisted of two experiments, named Experiment 1 and Experiment 2, consecutively. The participants' task was to click on the button labeled with the letter 'A' that served as the visual target on the computer screen. The participants of Experiment 1 heard no auditory clue that could help to locate the target letter; but instead, they saw the letter 'A' appeared on a red-colored square among other colorless letters. The participants of Experiment 2 heard a short melody or a single note just before they saw the circle of buttons. In experiment 1, participants had faster reaction times in trials with color than in trials without color. In Experiment 2, possible target locations were associated with a melody or single notes. Whole melody was found to shorten the average reaction time of the participants of Experiment 2. Single notes did not seem to improve the reaction time of the participants of Experiment 2.

Key Words

Auditory stimuli, visual search task, facilitation

Introduction

The perceptual system can utilize information acquired from one sensory modality to organize the perception in the other modality. There are many examples of intermodal influences (Vroomen & de Gelder, 2000). Indeed, in many studies, the arbitrary combinations of intermodal stimulus items have been reported to increase perceptual awareness compared with unimodal presentation of those items. More clearly, the term intersensory facilitation points out to more rapid reaction time (RT), to the target in one modality and an accessory stimulus in a different modality, compared to reaction time to the target alone (Bernstein, Chu, Briggs, & Schurman, 1973).

Modals of Intersensory Facilitation

Two types of hypotheses or modals have been emerged to explain intersensory facilitation. The first hypothesis points out to the energy integration across all the sensory modalities. And the second one attributes an alerting

function for the accessory stimulus. The first hypothesis, or energy integration model, claims that intensities of the visual and auditory events interact at some point in the nervous system (Bernstein, Chu, Briggs, & Schurman, 1973). In other words, to present a combination of light and tone event and to ask people to react according to the visual target of the combination is analogous for presenting a more intense visual target alone. The second hypothesis or preparatory state modal advocates that, an accessory stimulus acts as a warning signal. This modal implies that the magnitude of facilitation is greater with long foreperiod duration than short foreperiod duration. Bernstein, & Edelstein (1971) suggest that both of these hypotheses are necessary. In other words, they proposed that to be able produce facilitation both energy summation and alerting functions are important. On the other hand, Nickerson (1973) suggests that energy summation does not give a complete answer for the reaction time facilitation. In fact Nickerson (1973) advocates a preparation enhancement Model of facilitation. According to this modal, first of all, there is nothing intrinsically different about the visual or auditory channels. Both of them could elicit a response. Second of all, the accessory stimulus function as an alerting cue and the degree to which it facilitates one's response to the primary stimulus are depend on at least two factors. One of the factors involves the question of how well prepared the subject is when the accessory occurs. And the second one involves the question of how much time the arrival of the accessory at a decision center leads that of the primary stimulus. The modal emphasizes the enhancement of preparation to execute any stage of a sequence of events that intervenes between the occurrence of the stimulus and the execution of a response could have the effect of shortening reaction time. In this sense, preparedness to carry out a response would seem to be the most likely candidate for enhancement.

Characteristics of Intersensory Facilitation

In a study, Bernstein and his colleagues (1973) have proposed that intensity of accessory stimulus affects only false alarm rates on catch trials (an increased likelihood of responding) but not facilitation. In the experiment, they modified the intensity of light stimulus and tone stimulus. The participant's task was to react when an affirmative level of light (spot of light; bright or dim) followed the warning signal, regardless of (accessory tone) warning signal's intensity and to repress reaction if the light did not appear, regardless of whether a tone occurred. The results of experiment suggested that energy integration involved a form of response bias (increased likelihood of responding) but not more rapid information processing (Bernstein, Chu, Briggs, & Schurman, 1973).

Many experiments have been addressed to the question of what represents an optimal period of time (foreperiod) to lapse between the presentation of a ready signal and that of the stimulus to which the response is to be made (Nickerson, 1973; Bernstein, Clark, & Edelstein, 1969). Woodrow (1914) got a slightly longer RT with a foreperiod of 1 second than 2 seconds. In his experiments, the shortest reaction time was obtained at 4 seconds. Woodrow concluded that it takes between 2 to 4 seconds to reach a full attention.More recent works showed that preparation can be build up much faster than Woodrow argued. Teichner (1954) proposed that an optimal foreperiod duration is

somewhere between 1 and a few seconds. Some others suggest that foreperiod duration can be shorter than that, perhaps between 100 and a few hundred milliseconds (Bertelson, 1967; Bartelson, & Radeau, 1981). However, it is possible that this value may change with a number of factors.

Intersensory facilitation has been used to investigate the alerting characteristics of visual and auditory stimuli within a very large range of experimental conditions. Todd (1912) found Intersensory facilitation when sound and electric shocks were paired simultaneously. However, he found no effect when light was paired with either sound or shock. Hilgard (1933) used light and sound stimuli slightly offset in time. He found that the magnitude of the eye blink to sound was increased when the light preceded the sound by intervals of 25 msec. and 50 msec. Herhenson (1962) obtained reaction times (RT) to visual, auditory and combined visual auditory stimuli. Reaction times to combined visual auditory stimuli were faster than Reaction times to either visual or auditory stimuli alone. He also found that modifying the intensity of the stimuli differentially affected the magnitude of facilitation. Reducing the light intensity resulted in less facilitation whereas reducing the sound intensity had no effect.

According to more recent cuing literature, if an auditory cue precedes a visual target by between 100 msec. and 300 msec. can increase responding to that visual target (Vroomen, Gelder, 2000). The results of these experiments showed that auditory alerting stimulus was more effective than a visual alerting stimulus for intersensory facilitation to occur.

Posner, Nissen, and Klein (1976) also conducted a few experiments to show that the visual and auditory warning signals have different effects on visual and auditory tasks. In reaction time tasks, there is a sense that the processing of visual signals seems deficient in comparison with the processing of auditory stimuli. It appears that an auditory accessory is more effective than a visual accessory in reducing reaction time to vital stimuli. In other words, auditory stimulus is more effective than a visual stimulus when it comes to alerting function. Posner, Nissen, and Klein (1976) suggested that visual stimuli are less alerting than stimuli in other modalities. They suggested that relatively inferior alerting capability of visual signals might explain the tendency of vision to dominate other modalities. They also suggested that to balance for the low alerting capability of visual signals, participants display a general attentional bias toward the visual modality.

In a more previous work, Posner, Nissen, & Klein (1976) studied a cost and benefit analysis of intersensory facilitation mechanism. The idea behind a cost and benefit analysis was to separate active attention involving limited capacity mechanisms from the activation of pathways not involving these mechanisms. Posner, Nissen, & Klein, (1976) suggested that pure alerting activates the central processing mechanism and makes it available to any input item. It thus improves the speed of processing of all items that might be presented to the environment. To test this idea, they presented participants with blocks of trials, in which an auditory task occurred 80% of the time, 50% of the time, or 25% of the time. These particular trials were identified as expected modality trials. In remaining times, a visual task was presented. The purpose of the visual task was to create unexpected modality trials of the experiment. The

subject's task was to press one of the two keys to indicate whether a tone had appeared to the left or right of a centerline. They measured the cost of receiving signal in the expected modality and in the unexpected modality separately. They did the same processes for a visual task, as well. The results showed that both the auditory and visual modalities show significant costs in reaction time when they are unexpected and significant benefits when they are expected. One important but unexpected outcome of the cost and benefit analysis in both experiments was that the visual unexpected modality trials did not result in relatively greater costs than the auditory unexpected modality trials (Posner, Nissen, & Klein, 1976).

Proposed study involves a letter search task. It is designed to demonstrate the cross-modal effect of an auditory organization on a visual modality at a relatively low level of perceptual organization. Present study also focuses on the effect of cuing a visual target's location using auditory stimuli. In the study four different auditory stimuli was employed in order to examine the effect of auditory stimuli on a visual search task.

Experiment 1

Method

Participants

Ten undergraduate students of University of Nebraska at Lincoln (UNL) voluntarily participated in the experiment in turn for the course credit. All participants reported that to the best of their knowledge they had normal hearing, but no tests were made for possible unknown hearing abnormalities.

Apparatus

The apparatus consisted of a personal computer work station located in a cubicle of quiet and well-illuminated laboratory room. The work station included a chair and a desk with an IBM-type desktop or laptop computer with 15-inch monitor. Participants interacted with the computer by solely using the computer mouse.

Procedure

Description of the Experimental Task

In the beginning of each experimental session, participants were given verbal instructions about how the visual search task would be performed. To start the each trial, a participant had to press a button labeled "NEXT" that appeared alone at the center of the screen. Then the NEXT button disappeared and the screen changed to show the six buttons labeled with letters forming a circle around the center of the screen. Thus, the initial distance between each button and the mouse pointer used to click on buttons was the same, eliminating the possibility that one of the buttons could be picked more often merely because of its initial proximity to the pointer.

The Method of Administration

A complete experimental session consisted of 80 trials preceded by a training period lasting 10 trials. In each trial of the letter search experiment, participants were shown six buttons; each labeled with a letter of alphabet, and then, they were asked to click the button that had the letter A on it.

The size of the circle formed by the letter-labeled buttons was chosen just large enough to ensure that none of the letters on buttons would be

immediately visible to the subject whose vision was initially concentrated near the center of the screen. This required a brief visual search before the target letter could be picked. The contents of the screen changed randomly in every trial. The location of the letter A was one of the three fixed locations.

The first 10 trials were intended for training. In later 40 trials the letter A appeared on a red-colored square. Thus, the participants had a chance to store the fixed locations. Then the subject tried to locate A's without the help of color in the remaining 40 trials. In order to detect the changes in the task performance, reaction times were analyzed before and after the 40th trials.

At this point, we should note that experiment 1 does not employ auditory clues. In the absence of helpful clues, the participants' search times were determined by their reaction times to visual stimuli.

Results

According to 3 (form type) by 2 (trial blocks) repeated measures ANOVA test, there is a significant main effect of form ($F(2,18) = 4.737$, $Mse = 5891.445$, $p = 0.02$, $r = 0.34$). There is also a significant main effect of trial blocks ($F(1,9) = 11.947$, $Mse= 86273.563$ $p = 0.007$, $r = 0.57$). Pattern of scores suggests that participants overall had slower reaction times in trials without color (871.908 msec.) than in trials with color (609.780 msec.). The interaction between form type and trial blocks was found to be not significant ($F(2,18) = 1.960$, $Mse = 5896.163$, $p = 0.170$, $r = 0.17$).

Table 1 Means and Standard Deviations of trial block scores for form types

	Form 0	Form 1	Form 2
Before	672.6762 (152.4918)	573.6388 (95.5816)	583.0240 (92.4947)
After	886.4290 (327.3692)	836.3810 (256.9053)	892.9147 (285.3022)

Experiment 2

Method

Participants

Eleven new undergraduate students of University of Nebraska at Lincoln (UNL) voluntarily participated in the experiment in turn for the course credit. All participants reported that to the best of their knowledge they had normal hearing, but no tests were made for possible unknown hearing abnormalities.

Apparatus

The apparatus consisted of a personal computer work station located in a well- illuminated laboratory room. The work station included a chair and a desk with an IBM computer. In experiment 2, auditory stimuli were played back through the headphones worn by the participants connected to the headphone jacks of the computers.

Procedure

Description of the Experimental Task

All participants of experiment 2 were asked to keep the headphones on their ears all the time. This way it would be certain that they heard the auditory

stimuli preceding the trials. In the beginning of each experimental session, participants were given verbal instructions about how the visual search task would be performed.

To start the each trial, a participant had to press a button labeled "NEXT" that appeared alone at the center of the screen. Then the NEXT button disappeared and the screen changed to show the six buttons labeled with letters forming a circle around the center of the screen. As mentioned before, the initial distance between each button and the mouse pointer used to click on buttons was the same, eliminating the possibility that one of the buttons could be picked more often merely because of its initial proximity to the pointer.

The Method of Administration

In each trial of the letter search experiment, participants were shown six buttons; each labeled with a letter of alphabet, and they were asked to click the button that had the letter A on it. The size of the circle formed by the letter-labeled buttons was chosen just large enough to ensure that none of the letters on buttons would be immediately visible to the subject whose vision was initially concentrated near the center of the screen. This required a brief visual search before the target letter could be picked. The contents of the screen changed randomly in every trial. The location of the letter A was either one of the three fixed locations, or it changed randomly.

The first 10 trials were intended for training. In later 40 trials the letter A appeared on a red-colored square. Thus, the participants had a chance to store the fixed locations. Then the subject tried to locate A's without the help of color in the remaining 40 trials. However, the actual purpose of the experiment was to assess the role of auditory information in enhancing the performance of a subject in this visual search task. Therefore, in experiment 2, after the first 50 trials the experiment was modified to start each trial with a brief melody or a single note before the buttons with letters were displayed. Intersensory facilitation was expected to show its influence on the task performance differences between first 40 trials (before scores) and later 40 trials (after scores). In other words, in order to determine intersensory facilitation effect, the mean values of the performance measures (i.e., reaction time) were analyzed before and after the 40th trial. Auditory stimuli were expected to increase reaction time to the visual target after the 40th trial.

In addition to 3 fixed locations of A, letter A was also placed randomly in each trial. The melody or one of the single notes sounded right after the NEXT button was pressed, but before any of the six letter buttons appeared. One of the fixed locations of A was associated with a melody that included three notes. It was predicted that melody would supposedly help participants recall that specific locations and mark the letter faster. The other fixed locations or the random placement of A were associated with single notes that did not stand out much.

Results

In the table 2, we see the average reaction times and standard deviations depending on the location of A. Form values 0, 1, and 2 correspond to cases where A was fixed on one of three locations. Form 3 meant the location of A was chosen randomly. In Experiment 2, the participants were given a musical tone or a very short melody just before they saw the letter-filled screen in experiment

trials. Again, the letter A was placed in a colored square in training trials without sound and then the participants looked for A's in uncolored squares with sound. One of the fixed locations of A was associated with a melody that was supposed to help participants recall that specific locations and mark the letter faster. The other fixed locations or the random placement of A were associated with single notes that did not stand out much.

According to repeated measures ANOVA there is a significant interaction between trial block scores and form ($F(3,30) = 10.756$, $p = 0.00$, $r = 0.518$, $Mse = 34839.369$). There is also a significant main effect of form ($F(3,30) = 7.666$, $p = 0.001$, $r = 0.434$, $Mse = 57446.904$). According to the patterns of corresponding simple effects of form at before trials none of the forms are significantly different from each other ($F(3,30) = 0.272$, $p = 0.845$, $Mse = 65939.591$, $r = 0.026$). However, when we look at the simple effects of form at after trials form 0 is significantly different from form 1 and 3. And form 3 is significantly different from form 0, 1 and 2 ($F(3,30) = 30.258$, $p = 0.00$, $Mse = 26346.682$ $r = .75$)

There is also a significant main effect of trial block scores ($F(1,10) = 5.998$, $p = 0.034$, $r = 0.375$, $Mse = 163285.732$). Participants had shorter reaction times in earlier trials (mean= 847.151 msec. for before) than in later trials (trials with sound but no color) (mean = 1058.146 msec. for after). This effect was potentially descriptive for form 3 (random placement of A) because the pattern of corresponding simple effects showed that means for after trials are longer than the means for before trials and this effect was significant ($F(1,10) = 59.435$, $Mse = 31005.388$, $p = 0.00$, $r = 0.85$). This effect was potentially misleading for form 0 (distinct melody) because the pattern of the corresponding simple effects showed that means for the after trials are shorter than those for the before trials. However, this effect was not statistically significant ($F(1,10) = 0.009$, $Mse = 112104.061$, $p = 0.928$, $r = 0.01$). As we can see from table 2, the reaction times associated with the fixed location 0 in earlier trials were longer than it was in later trials. That was the location associated with the melody. The two other fixed locations (1 and 2) had reaction times longer in later trails than in earlier trials. When the letter A was randomly placed (Form value 3) the sound did not help at all. The reaction time was longer than all forms.

Separate analyses also were then performed to compare experiment 1 no sound trials with experiment 2 sound trials for form 0 (location associated with the distinct melody). Since the differences between two experiments were of interest, form 0's treatment conditions in each experiment were compared using one degree of freedom F test (i.e. t test). Means for the no sound trials are longer than those for the sound trials. However, this effect was not statistically significant either and therefore must await further study before it can be incorporated into facilitation idea ($t(19) = 0.821$, $p > 0.05$.).

Table 2 Means and Standard Deviations of before after scores for form types

	Form 0	Form 1	Form 2	Form 3
Before	795.0993 (290.1173)	857.4650 (362.5480)	892.4865 (175.2855)	843.5513 (161.7668)
After	781.9015 (245.4403)	1061.8891 (174.3473)	966.3999 (311.7089)	1422.3935 (227.8481)

General Discussion

Previous research had shown that irrelevant auditory and visual cues enhance the stimulus processing. In other words, reaction times (RT) were faster with the combination of stimulus than the stimulus alone. If an individual is set to respond to either an auditory or a visual stimulus, his or her reaction time to primary stimulus tends to be shorter when this stimulus is accompanied or closely followed by an irrelevant accessory stimulus than when it is presented by itself. Secondly, varying the intensity of the stimuli differently affect the magnitude of facilitation.

In the present study, we demonstrated a cross model phenomenon. Results of this study indicated that the speed of responding to a simple visual display was affected by the presentation of visual and auditory stimulation. This effect was observed when a visual stimulus (i.e., color) was used. This effect also was observed when a melody was used, but this effect was greatly diminished when a single tone was used. It should be kept in mind however, that this effect was not statistically significant and must await further study before it can be incorporated into facilitation idea. Nevertheless, these results may indicate that the whole melody became more distinct for the participants than the single tone. Therefore, it caused faster response times than the single tones. As we know from the cross modal facilitation literature, especially in the study of Vroomen and de Gelder, (2000), the intersensory facilitation effect was greater when a more distinct tone has been used, compared to a less distinct tone. They concluded that if sequences of sounds can be arranged into perceptual organizations of sounds that would have great effect on cross modal facilitation. It is the fact that everyday sounds are labeled just a mere noise and judged to be different from melody. Davies (1978) notes that common people have little difficulty in distinguishing music or melody from other collections of sound events. It seems that musical melodies are more distinguishable and recognizable. For that reason, it is possible that in the present study whole melody created more profound effect than the single tones. The most importantly, this effect disappeared when the target was unpredictable. In other words, the intersensory facilitation was effected by whether or not the target was predictable. That particular result is also consistent with the results of the study done by Posner, Nissen, & Klein, (1976). More studies can be done for further study that effect.

There is a wide variety of neurophysiological findings that show interactions between vision and audition in several cortical and subcortical areas. According to this variety of neurophysiological findings, humans are born with massive interconnections among the different sensory pathways in the brain. In humans, several studies have found neural sites of multisensory convergence. Studies on cross modal facilitation can give us a more complete explanation of the relationship between the activation of different pathways in the nervous system and the activation of attentional systems. In addition, future studies could investigate whether cross modal effects can be observed across other modalities rather than the auditory and visual.

References

BERTELSAN, Paul., & RADEAU, M. (1981), "Cross-modal bias and perceptual fusion with auditory- visual spatial discordance", **Perception & Psychophysics, 29**, 578- 584.

BERNSTEIN, Ira, H., CHU, Philip. K., BRIGGS, Patricia., & SCHURMAN, Donald. L. (1973), "Stimulus intensity and foreperiod effects in intersensory facilitation", **Quarterly Journal of Experimental Psychology, 25,** 171-181.

BERNSTEIN, Ira, H., CLARK, M. H.,& EDELSTEIN, Barry. A. (1969), "Effects of an auditory signal on visual reaction time." **Journal of Experimental Psychology, 80**, 567-569.

BERNSTEIN, Ira, H., CLARK, M. H.,& EDELSTEIN, Barry. A. (1969), "Intermodal effects in choice reaction time", **Journal of Experimental Psychology, 81,** 405-407.

BERNSTEIN, Ira, H.,& EDELSTEIN, Barry. A. (1971). "Effects of some variations in auditory input upon visual choice reaction time", **Journal of Experimental Psychology, 87,** 241- 247

BERTELSON, Paul. (1967), "The time course of preparation", **Quarterly Journal of Experimental Psychology. 18,** 272-277.

HERSHENSON, Maurice. (1962), "Reaction time as a measure of intersensory facilitation", **Journal of Experimental Psychology, 63,** 289- 293.

HILGARD, E. R. (1933), "Reinforcement and inhibition of eyelid reflexes", **Journal of Experımental Psychology: General 8,** 85-113.

NICKERSON, Raymond. S. (1973), "Intersensory facilitation of reaction time: Energy summation or preparation enhancement?", **Psychological Review, 80**, 168-173.

NISSEN, Mary. J. (1974), **Facilitation and selection: Two modes of sensory interaction.** Unpublished master's thesis, University of Oregon.

POSNER, Michael. I., NISSEN, Mary. J., & KLEIN, Raymond. M. (1976), "Visual dominance: An information- processing account of its origins and significance", **Psychological Review, 83,** 157- 171.

SIMON, J., Richard,& CRAFT. JOHN. L. (1970), "Effects of an irrelevant auditory stimulus on visual choice reaction time." **Journal of Experimental Psychology, 86**, 272- 274.

TEICHNER, W. H. (1954), "Recent studies of simple reaction time", **Psychological Bulletin, 51**, 128- 149.

TODD, J. W. (1912), "Reaction to multiple stimuli", **Arch. Psychology,3**,25.

VROOMEN, Jean, & DE GELDER, Beatrice. (2000), "Sound enhances visual perception: cross modal effects of auditory organization on vision", **Journal of Experimental Psychology: Human Perception and Performance, 26,** 1583- 1590.

WOODRAW, H. (1914), "The measurement of attention", **Psychological Monogram, 76**, 17.