REACTION TIME AS A MEASURE OF INTERSENSORY FACILITATION

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In measuring reaction time (RT) to simultaneously presented stimuli, Todd (1912) found facilitation when sound and electric shock were paired but no effect when light was paired with either sound or shock. These results may be understood using the scheme suggested by Hilgard (1933) to account for facilitation of the eyeblink reflex. Hilgard used light and sound stimuli slightly offset in time and found that the magnitude of the eyeblink to sound was augmented when the light preceded the sound by intervals of 25 and 50 msec. Thus, he maintained, there was a summation of “reaction tendencies” when the stimuli were presented at an interval equal to the differences in the latencies of their respective responses. Since the latency for light is greater than that for sound, the light must precede the sound in order for “response tendencies” to occur simultaneously. Indeed, Hilgard suggests that the difference between the latencies for the single stimuli may be the point of maximum facilitation.

When taken together these two studies present a coherent picture. Since sound and shock yielded very similar RTs, no stimulus onset asynchrony (Δt) was necessary for simultaneity of response tendencies to result in facilitation. Similarly, facilitation should not have been expected for light and sound or light and shock when presented simultaneously since light yielded much longer RTs than either sound or shock.

The experiment to be reported was designed to study the effects of stimulus onset asynchrony on RT to paired light and sound stimuli. According to the above analysis, facilitation should be expected when the light and sound stimuli are offset in time by an amount approximately equal to the difference between the RTs to the single stimuli. The RT to this presentation should be faster than to either stimulus alone and the maximum effect should occur when Δt equals the difference between the RTs to the stimuli when presented singly. Since stimulus intensity is an important determiner of RT to single stimuli, variation of intensity might also affect facilitation. This was another variable used in the study.

METHOD

Light.—The light stimulus was produced by pulsing a glow modulator tube (Sylvania R-1131C) in the plate circuit of a 6L6 vacuum tube with rectangular pulses from a Tektronix pulse generator. The glow modulator tube was mounted in a light-tight box with a circular aperture, 1 cm. in diameter, directly in front of the tube. The light was diffused over a ground glass plate placed in front of the lamp and pressed against the inside front face of the box. The aperture, viewed binocularly from a headrest 50 cm. away, subtended 1° 10' of arc.
### TABLE 1
**MEAN RTs (MSEC.) FOR SUBJECT SR**

<table>
<thead>
<tr>
<th>Δt (Msec.)</th>
<th>Stimulus</th>
<th>Light</th>
<th>Light &amp; Sound</th>
<th>Sound</th>
<th>Light &amp; Sound Minus Δt</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
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<tr>
<td>0</td>
<td>149</td>
<td>11.1</td>
<td>98</td>
<td>6.3</td>
<td>97</td>
</tr>
<tr>
<td>5</td>
<td>144</td>
<td>10.6</td>
<td>99</td>
<td>5.3</td>
<td>94</td>
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<td>144</td>
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<td>25</td>
<td>144</td>
<td>8.5</td>
<td>121</td>
<td>6.2</td>
<td>94</td>
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<tr>
<td>35</td>
<td>149</td>
<td>7.8</td>
<td>131</td>
<td>3.9</td>
<td>96</td>
</tr>
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<td>45</td>
<td>149</td>
<td>10.1</td>
<td>138</td>
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<td>97</td>
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<tr>
<td>55</td>
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<td>8.3</td>
<td>141</td>
<td>6.6</td>
<td>100</td>
</tr>
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<td>65</td>
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<td>10.5</td>
<td>144</td>
<td>4.7</td>
<td>104</td>
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<tr>
<td>75</td>
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<td>7.8</td>
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<td>8.2</td>
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</tr>
</tbody>
</table>

Note.—Stimuli: L & S; L - S = 49.8 msec. Each cell mean was based on 72 RTs.

Two luminances were used covering two log units. The unfiltered stimulus (L) was approximately 3000 ft-L as measured by a Macbeth illuminometer at the ground glass plate. An ND 2 Kodak filter was inserted between the glow modulator tube and the ground glass screen to produce the weaker stimulus (l). Light flashes were all 250 msec. in duration. A white cardboard ring, .75 cm. wide and 6.5 cm. in outside diameter, surrounded the stimulus aperture and served as a fixation device.

**Sound.**—A noise burst of 50-msec. duration was presented by closing a high speed relay with pulses from another Tektronix pulse generator. This stimulus, produced by a Grason-Stadler noise generator (Model 455B), was delivered through an audio amplifier to a set of Telephonics headphones. Two sound levels were used for both Ss. The sensation levels corresponding to these intensities were 95 db. (S) and 75 db. (s) for Subject SR, and 85 db. (S) and 65 db. (s) for Subject MH.

**Timing.**—Both pulse generators were triggered from a Tektronix wave-form generator which allowed for the introduction of stimulus onset asynchrony. All critical timing functions depended on voltages which were regulated to better than 0.1%. All durations and time intervals were checked by means of a Berkeley counter (Model 7350). The RTs were measured by the counter to ±1 msec. For Subject MH, the counter was started by the light pulse for all measurements. For Subject SR, the counter was started in a similar manner except for the sound RT where the sound pulse triggered the counter. In all cases, the counter was stopped when S depressed a normally closed telegraph key.

**Procedure.**—The S was seated in a sound-proof and light-proof room which was dimly illuminated from above and behind S by a 6-v. lamp enclosed in a light-tight box with a 5.5-cm. circular opening covered with several sheets of tissue paper. The luminance at the paper surface measured 22 ft-L. This lamp was 120 cm. from the ground glass plate.

Each trial was introduced by a 1000-cycle warning tone lasting 1 sec. which was delivered through a loud speaker in the chamber. This was followed by one of three silent foreperiods of 2, 2½, or 2½ sec. selected according to a previously recorded random order. The stimulus was presented at the end of this foreperiod. The entire sequence was controlled by Hunter decade interval timers connected to present one trial every 13 sec.

A block of trials consisted of 20 reactions to a particular stimulus. Three blocks—light alone, sound alone, and the combination of light and sound with a particular preset asynchrony—made up a series. Two series were given in each session which lasted for approximately 1 hr. The sequence of the blocks was changed from series to series.

Each session began with 5 min. of dark adaptation. Four practice trials were given before each block and a 2-min. rest period was given between blocks. The S was instructed to respond as quickly as possible to the first stimulus perceived. Introspective
reports indicated that for all asynchronies the stimuli seemed "simultaneous."

The longest and shortest RTs for each block were discarded leaving 18 RTs per block. Each asynchrony was tested over two sessions (i.e., four blocks per condition) which yielded a total of 216 RTs (72 light, 72 sound, 72 light-sound).

Subjects.—The Ss were one undergraduate student (SR) and the author. Both were well practiced.

RESULTS

Table 1 contains mean RTs and SDs for Subject SR. The values of asynchrony indicate the amount by which the light preceded the sound for the pair RTs. In no instance did the sound precede the light.

The small differences in the mean RTs to light alone and sound alone reflect day-to-day variations. RTs to the light-sound pairs were measured from the onset of the light. If these means represented responses to the sound alone (no facilitation) we would expect the RT to increase by the amount that the light preceded the sound ($\Delta t$). The values should get progressively larger therefore, until the point where the RT to the combination equals the RT to light. The means should then remain fairly constant.

Values for RTs to the light-sound pairs minus the asynchrony indicate response latencies as if measured from the onset of the sound. Evidence for facilitation can be seen at those asynchronies where the RT to light-sound measured from the onset of the light is faster than to light alone and RT to light-sound measured from the onset of the sound is faster than to sound alone.

Figure 1 shows the curves of facili-
tation as a function of asynchrony. These were derived from Table 1 and similar tables for Subject MH in the following way: first, overall means for all sessions were obtained for the RTs to light alone and sound alone (the best estimate of the RTs). The difference between these means is represented on the graphs as a vertical dashed line. Comparisons to the right of this line were made to light alone and those to the left of the line were made to sound alone. All comparisons were made using mean RTs which were obtained during the same sessions thereby minimizing the effects of practice and day-to-day variability.

Ordinate values were obtained simply by subtracting the RT to the pair from that to the single stimulus in accordance with the scheme outlined above. Thus a zero difference indicates no effect, a positive value indicates facilitation, and a negative value indicates inhibition. Fiducial intervals ($P = .05$) were calculated separately for each single RT mean with which comparisons were made at each asynchrony. The extent of each interval is indicated above and below the zero facilitation baseline.

It is evident that RT to paired light and sound stimuli can be facilitated by the introduction of stimulus onset asynchrony. All four curves indicate that the facilitation was a U shaped function of stimulus asynchrony with maximum facilitation in the region of the point at which the asynchrony is equal to the difference between the RTs to the single stimuli. These results are consistent with our hypotheses.

Individual differences are easily noted by comparing the curves for the most intense stimuli for 2 different Ss (Fig. 1, a and b). The fact that the RTs to the same single stimuli were different for the 2 Ss is reflected in the shift of the dashed line. A more important but less understandable shift was observed for Subject SR who showed maximum facilitation a full 15 msec. after the point of "physiological simultaneity." Thus for the same physical stimuli, RTs for the 2 Ss were differentially affected by stimulus asynchrony whereas the magnitude of the facilitation was quite similar.

A comparison of Curves b and c in Fig. 1 (both curves for Subject MH) indicates that a change of 2 log units in the intensity of the sound had only a minor influence on the magnitude of the facilitation. However, the curves shifted appropriately in relation to the difference between the mean light RT and the mean sound RT, i.e., as expected, the maxima always fell near this point. On the other hand, examination of Curves c and d in Fig. 1 (also for Subject MH) reveals that a diminution of 2 log units in the intensity of the light stimulus yielded less facilitation. An appropriate shift in the maximum effect is again evident.

The $SD$s were quite small throughout indicating fairly consistent reactions to all stimuli (see Table 1). RTs to sound were generally more consistent than those to light. The $SD$s of the pair RTs were generally smaller than those of the RTs to the single stimuli at those asynchronies where facilitation was found. This trend fell short of significance however, a $t$ test for correlated means comparing the pair $SD$s to the smaller of the two single stimulus $SD$s in the region of facilitation yielded a one-tailed $P$ of .07.

**Discussion**

The data clearly demonstrate intersensory facilitation for paired suprathreshold light and sound stimuli. It
is further evident that this effect will be manifest only when one "gives the stimuli a chance," i.e., introduces the proper amount of stimulus onset asynchrony. Since the amount of asynchrony necessary for facilitation is determined by the difference between the means of the RTs to the stimuli when presented singly, the value will differ from $S$ to $S$.

That facilitation was not due to attitudinal factors is indicated by the fact that it was a function of stimulus asynchrony and that all four curves were similar in shape. If the mere presence of one stimulus had an "alerting" or "orienting" effect on the reaction to the other stimulus, one would have expected this effect to show up at all asynchronies that were measured. Although the data cover only a small range of asynchrony, it is obvious that this was not the case.

The trend in the SDs may be further evidence that facilitation was not due to an alerting function of one of the two stimuli for, if this were so, it is hard to see how SD should be related to asynchrony. It should be kept in mind however, that this trend was not statistically significant and must await further study before it can be incorporated into our conception of facilitation.

Another finding that is difficult to understand is the different effect of intensity of the two stimuli. Why should a 2 log unit change in the luminance of the light effect the magnitude of facilitation whereas a similar change in the sound showed no effect?

There is some hint of inhibition in the data. The negative values (Fig. 1a) show that the RTs to the combination were slower than to either stimulus alone. Although this effect seems to be rather small, the values at 25 and 50 msec. asynchrony are statistically significant and indicate that this region warrants further investigation.

**Summary**

An experiment is reported in which RTs were measured to light and sound presented singly and in combination. The chief experimental variable was stimulus onset asynchrony. The results may be summarized as follows: (a) Intersensory facilitation was demonstrated in that, for certain asynchronies, RTs were faster to the combination than to either stimulus alone. (b) Maximum facilitation occurred at or just beyond the point at which the asynchrony was equal to the difference in RT to the single stimuli. (c) Varying 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.

**References**


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