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Stimulus recycling and ring-disk masking

ALFRED B. KRISTOFFERSON and PATRICIA ANN KOWALIK
McMaster University, Hamilton, Ontario, Canada

When disk-followed-by-ring stimulus pairs are presented in a continuous, recycling sequence, the amount of masking of the disk depends on the intercycle interval (ICI) as well as the interstimulus interval (ISI). As ICI increases, masking increases until ICI reaches about 350 msec. Thereafter, successive pairs appear to be independent of each other. Maximum masking occurs at a stimulus onset asynchrony of about 90 msec, regardless of ICI. When ICI is relatively small, it becomes possible to organize the pairs into ring-followed-by-disk, and there is little or no masking. Temporal organization takes precedence over masking.

The Type B visual masking function obtained when a disk (the target) is masked by a ring (the mask) shows that masking is greatest when the mask follows the target by a time interval between 50 and 100 msec. When the target and the mask are simultaneous or when the ring occurs first, little or no masking occurs. This generalization was stated by Kahneman (1968) and has held up over the years (Breitmeyer, 1984).

Under certain conditions a Type A function is obtained, in which case masking is maximum when target and mask are simultaneous and decreases monotonically as stimulus onset asynchrony (SOA) increases. The conditions that yield each of these types of functions are now quite well defined. Breitmeyer (1984) also showed that as one of these conditions is systematically varied, the function changes in shape from Type B to Type A in a progressive fashion so that the SOA of maximum masking becomes progressively smaller and the amount of masking at an SOA of 0 msec progressively increases as the proportion of Type A in the "mixture" increases. The inference that peak masking occurs at an SOA near 100 msec for the Type B mechanism has much support.

Werner (1935), in a paper that continues to be one of the most influential on this topic, was probably the first to report Type B functions. Because he did not report quantitative data, and because of certain ambiguities in his presentation, it is not possible to be certain of this. It is our interpretation that he was observing Type B functions and that he found maximum masking at SOAs very substantially greater than 100 msec.

Werner (1935) spoke of "optimum" masking in phenomenological terms. When the SOA separating the target (a disk) and the mask (a ring) was within a certain range, masking was optimum: 80% of the time no trace of the disk could be seen within the ring, 7% of the time the inner field of the ring was actually whiter than the surround, and 13% of the time it was somewhat gray. Optimum SOAs fell in the range 132-265 msec. Also, for each individual subject there was a point within that range at which the phenomenon (of masking) was "clearest." Therefore, maximum masking seems to have occurred at SOAs in the neighborhood of 200 msec. Half of Werner's subjects could, by an exercise of their volition, achieve complete disappearance of the disk at SOAs as great as 300 msec.

There is a feature of Werner's (1935) experimental procedure that might account for the large disparity between his results and all results reported since. He recycled the stimulus pairs so that a trial consisted of a sequence of pairs. One cycle within a sequence consisted of a brief exposure of the disk, followed by a dark empty field of duration equal to the interstimulus interval (ISI), followed by a brief exposure of the ring, followed by the dark field again of duration equal to the intercycle interval (ICI). Then the cycle repeated. Werner stated that the disappearance of the disk reaches an optimum after a requisite number of repetitions (cycles), but provided no data on that. He also maintained that the recycling is essential to obtain disappearance of the disk and that optimum masking is obtained when ICI is within the range 280-560 msec, implying that the magnitude of masking is a nonmonotonic function of ICI.

We have been able to find only two papers since Werner's (1935) that consider recycling and ICI. Kolers and Rosner (1960) used recycling, but 1,500 msec was their shortest ICI. Schiller and Smith (1968) reported one experiment on recycling, which yielded information for three values of ICI at a single value of ISI. Neither of these is very informative, although Schiller and Smith did show clearly that decreasing ICI below 170 msec markedly reduces the magnitude of masking when ISI = 60 msec.

Werner's (1935) report of his experimental procedures is incomplete in several respects. No information is given on such crucial factors as stimulus size and eye fixation. Therefore, replication of his experiments is not possible. We have done numerous exploratory experiments on ring-disk masking using recycling, under conditions as similar to Werner's as we could contrive (Kowalik, 1986),

Please address correspondence to Alfred B. Kristofferson, Department of Psychology, McMaster University, 1280 Main Street West, Hamilton, ON L8S 4K1, Canada.

and we have consistently found that maximum masking, as revealed by phenomenal report, occurs at values of ISI that are much smaller than those reported by Werner.

Nonetheless, recycling the stimulus pairs is an important variable, and we report here two experiments that demonstrate the effect of intercycle interval.

METHOD

The stimuli were two black disks, on a white background, presented together in one field of a Gerbrand's G1136 four-field tachistoscope and a ring that was presented in a second field. The disks were side by side, with their centers on the horizontal meridian and a fixation point midway between them. Disk diameter was 1.1° of visual angle, and their centers were separated by 4.4°. The inside diameter of the ring was 1.1°, its outside diameter was 1.5°, and the ring was located concentric to the area occupied by the right-hand disk. The fixation point was a dim light that was on continuously. Field intensities were 1,850 lm/m². Viewing was binocular. Trials were randomized, and the experiment was controlled by computer.

One stimulus cycle consisted of a 12-msec presentation of the field containing the two disks, followed by darkness for the duration of the ISI, followed by a 12-msec presentation of the ring field, followed by darkness for the duration of the ICI; then the cycle repeated. The recycling stimuli, which continued as long as the subject desired, was terminated by the response for that trial.

In Experiment 1 there were 4 values of ISI and 12 values of ICI. In Experiment 2 there were 12 values of ISI and 4 values of ICI. The values used are given in the figures and tables. In each experiment, a series consisted of 48 trials, one of each of the 48 combinations of ISI and ICI. Each subject ran 10 series. Each trial was initiated by the subject.

The disk on the right was the target and the one on the left was the standard. The task was to rate the appearance of the target in comparison to the standard on an 11-point rating scale. A rating of 10 indicated that the target was perceived to be exactly the same as the standard. A rating of 0 indicated complete absence of the target, or total masking. Intermediate ratings indicated that the target differed in brightness, contour, form, or figural identity from the standard, with the weighting of such factors left up to the subject. A rating of 11 meant that the target appeared blacker and clearer than the standard.

Five adult subjects participated in Experiment 1, including the 2 authors. Only the 2 authors took part in Experiment 2.

RESULTS

For each of the 48 combinations of ISI and ICI, the mean rating was calculated for each subject and then for all subjects combined. Since a rating of 10 represents zero masking, and 0 represents complete masking, these means were subtracted from 10 to give the magnitude of masking (M). The resulting values are given in Table 1 and Figure 1 for Experiment 1.

Figure 1 shows that M was a strong function of both ICI and ISI. Maximum masking was obtained for an ISI = 90 (SOA = 102). As ICI was increased, M increased rapidly and then leveled off. There was no indication of nonmonotonicity. These main results are clearly evident in the data for each individual subject.

Multiplying the values of M by an appropriate constant for any one ISI in Figure 1 satisfactorily superimposed the curve for that ISI upon that for any other ISI. Lateral translation added little to the goodness of the superimposition fit. When all four curves were so superimposed and averaged, it was clear that M was unaffected by ICI when ICI exceeded approximately 350 msec. The largest ICI is 1,200 msec. In another experiment (Kowalik, 1986), ICI was extended to 2,500 msec and no further change in M was obtained. We conclude that when ICI exceeds 350 msec, the successive pairs in a recycling sequence are independent of each other and are equivalent to single-pair presentations.

In a recycling sequence, cycle time is the sum of ISI and ICI, plus the durations of the ring and the disk. Cycle time is the rate at which the pairs are presented. Replotting Figure 1 using cycle time rather than ICI gives a set of curves that require substantial lateral translation in addition to vertical multiplication to achieve superimposition.

The most acceptable conclusion at present is that ICI is the important variable. When ICI exceeds 350 msec, the successive pairs are independent, regardless of ISI. As ICI is decreased below 350 msec, the amount of mask-

Table 1
Mean Magnitude of Masking as a Function of Interstimulus Interval (ISI) and Intercycle Interval (ICI) for All Subjects of Experiment 1

	ISI (in msec)			
ICI	50	90	150	200
100	2.9	2.6	0.3	0.4
200	5.0	4.9	1.8	0.9
300	5.8	7.6	4.2	1.7
400	6.1	8.6	4.0	2.1
500	6.5	8.3	5.0	2.0
600	6.6	8.1	4.2	2.1
700	6.4	8.5	4.9	2.1
800	6.6	8.4	4.3	1.5
900	6.8	8.6	4.6	1.7
1000	6.4	8.7	3.9	1.6
1100	6.5	8.2	4.3	1.6
1200	6.3	8.2	4.1	2.1

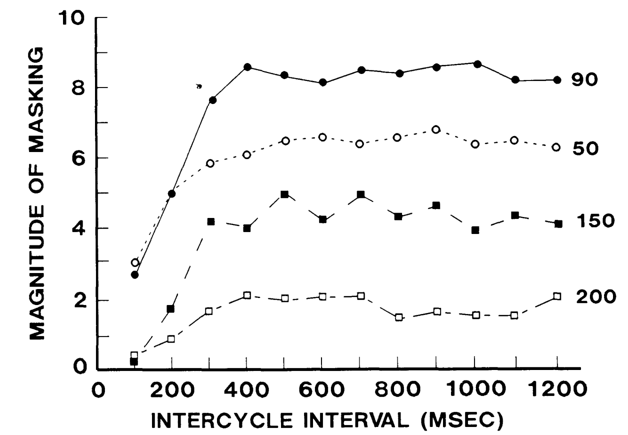

Figure 1. Magnitude of masking as a function of intercycle interval. The parameter is interstimulus interval. Mean ratings for 5 subjects, Experiment 1.

Table 2
Mean Magnitude of Masking for the 2 Subjects of Experiment 2

ISI	ICI (in msec) 50	150	250	600
0	−0.4	−0.3	−0.1	0
20	0.4	0	0	0
40	4.5	4.4	4.1	4.0
60	5.6	6.4	7.7	6.6
80	5.8	7.2	8.3	9.8
90	5.1	6.2	8.2	9.6
100	4.8	5.8	7.2	9.3
120	3.5	4.3	6.7	7.7
140	2.9	3.4	5.3	6.1
160	2.5	2.9	4.6	4.1
180	1.6	2.2	3.1	3.0
200	1.7	1.9	2.5	2.0

ing decreases and appears to be going toward zero, even though the pairs are occurring closer together in time.

Figure 2 displays the results of Experiment 2 and reveals in greater detail the effect of ICI on the masking function. These data are averages for only 2 of the 5 subjects of Experiment 1, but there is general agreement between the two experiments. The numerical data are given in Table 2.

Peak masking occurred at an ISI of 80 msec for every value of ICI. This corresponds to an SOA of 92 msec. As ICI was decreased below 350, the overall amount of masking decreased progressively. However, when ISI was less than about 50 msec, decreasing ICI to values as low as 50 msec had no effect.

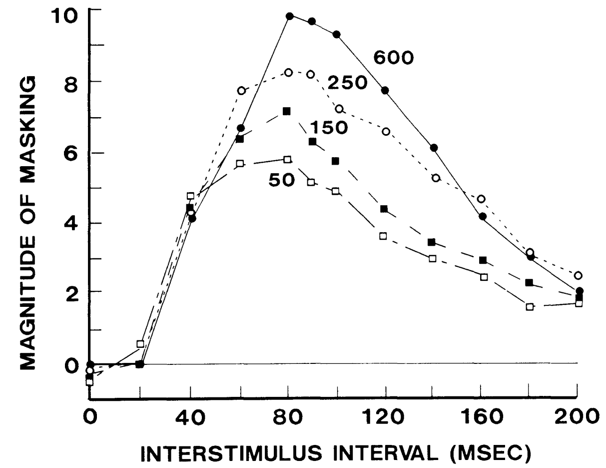

Figure 2. Magnitude of masking as a function of interstimulus interval. The parameter is intercycle interval. Mean ratings for the 2 subjects of Experiment 2.

DISCUSSION

These experiments showed that the magnitude of masking is not a nonmonotonic function of the intercycle interval when the disk and the ring are presented in a recycling sequence. This is contrary to the strong implications about this matter in the early papers by Werner (1935) and Kolers and Rosner (1960). There is also no indication that the peak of the masking function is shifted to SOA values greater than 100 msec as a result of recycling.

The results show that ICI does affect the magnitude of masking, but only when the ICI is less than 350 msec, in which case decreasing it markedly reduces masking.

It is fairly obvious that masking must be minimal when ICI is small. For example, if SOA were fixed at 100 msec, then masking is complete when ICI is long. Reducing the ICI to zero would result in simultaneous presentation of the disk and the ring. Reducing ICI to zero is equivalent to setting the ISI at zero and results in a phenomenal report of "no masking" because the disk and the ring together are, in both cases, equivalent as stimuli to a disk with a diameter equal to the outer diameter of the ring. In a sense, the stimulus forces the ring and disk to be organized together and seen as a large disk recurring every 100 msec.

When ICI is greater than zero but small and ISI is still 100, the tendency to organize the disk together with the ring that precedes it (rather than the one that follows it) must persist. There is little or no masking of a disk by a ring that precedes it. Therefore, to the extent that the stimuli are so organized, net masking will be diminished. The only surprising finding of these experiments is that this tendency exists for ICIs as long as 350 msec.

Figure 2 shows that when ISI is less than 50 msec, values of ICI as small as 50 do not diminish masking. At small values of ISI, the organization into disk followed by ring is too difficult to overcome.

This means that temporal organization takes precedence over masking. This variety of masking is not solely determined by SOA. Instead, temporal organization has priority. The masking that occurs depends on the particular temporal organization that is achieved.

It is possible that certain "disinhibition" phenomena that have been observed in visual masking can be explained in terms of temporal organization. The effect of small ICI shown in this paper is a variety of disinhibition.

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