Range Estimation Error as a Function

of Stimulus Movement Rate

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Range Estimation and Stimulus Movement

Summary

The primary goal of this research was to study errors in stadi-metric estimation. Earlier workers had hypothesized that differences in angular velocity of stimuli associated with direction of movement resulted in differences in error between incoming and outgoing stimuli. Therefore, an experiment was performed which, investigated differences in range estimation error as a function of three movement rates. The results showed that errors were consistent regardless of rate of movement.

Range Estimation Error as a Function

of Stimulus Movement Rate

Previous studies (McClusky, 1971; McClusky, Wright, and Frederickson, 1968) evaluated a simple occlusion device as a ranging aid or range-finder. This device allows the observer to measure the distance of an object of known size by matching the target's apparent size with a standard which subtends the same visual angle as the object at a known distance. In these studies, the experimenters were interested in the ability to estimate a single range. The most extensive of these studies (McClusky, et al., 1968) used a simple device with a chin-rest which fixed the distance from the eye to the standard device. The target object was a model aircraft which could be moved on a course directly at or away from the observer. A striking finding was a statistically significant difference in error between the incoming and outgoing targets, with the outgoing targets being associated with a large error of underestimation.

McClusky (1971) hypothesized that the observed incoming-outgoing differences would decrease with decreasing target speed and as the range to be estimated increased, except for very short ranges. This hypothesis was based on an analysis of the rate of change of the angular subtense of the target. This analysis revealed that the curve relating rate of change to distance was essentially flat (i.e., the rate of change was nearly zero) for the incoming target just preceding coincidence with the standard (1500 meters). However, the section of the curve preceding the outgoing coincidence

had a relatively sharp slope, indicating a rapid change in sub-
tended angle. The effect of this difference in angular rate on an
observer judgment is based on two primary assumptions: (1) the tar-
get behavior during the interval preceding coincidence with the
standard provides information to the observers which is relevant to
their judgment; (2) the observers do, in fact, attempt to antici-
pate the coincidence event (i.e., the occurrence of equal angular
subtense for both standard and target) on the basis of the observed
rate of change of target size. An estimate of the coincidence event
for 1500 meters for the incoming direction based on a constant rate
of angular change would reflect only reaction time, since the rate
of change is essentially zero. However, an attempt to predict the
coincidence event for the outgoing direction should result in an
underestimation, since the rate of angular change of the target
abruptly enters a period of non-linear deceleration just before the
coincidence event. This (McClusky's) hypothesis prompted an experi-
ment designed to test its validity and the validity of the under-
lying assumptions.

Method

The stimulus presentation equipment for the range estimation
task consisted of an oscilloscope driven by a variable frequency
oscillator. The oscilloscope displayed a moving bar target which
simulated an aircraft in flight to or away from the observer's

eye. The target exhibited only radial motion and expanded pro-
portionally. The oscilloscope was placed at one end of a seven-
foot long light-tight box. An internally illuminated plexiglass
post was placed part way down the box where it subtended an angle
equal to that subtended by the target at a scale distance of 1500
meters. The target size and distance values were the same as those
used by McClusky (1971). The observer was seated at the opposite
end of the box and observed the target and post monocularly. A 1X
terrestrial telescope was provided to eliminate accommodation cues.
Viewing was with the dominant ·,e in all cases. To minimize ob- .
server fatigue, an adjustable chin-rest was provided. The beginning
of a trial was signaled to the observer by an indicator light.
After approximately three seconds, the target appeared in motion at
a scale distance of either 500 or 2500 meters depending on whether
an outgoing or incoming trial ᵥ as being presented. The stimulus
was presented in movement toward or away from the observer at
scale speeds of 200, 300, and 400 knots.

The observer was instructed to signal his judgment of the coin-
cidence event by pressing a switch, after which the target dis-
appeared. A digital voltmeter displayed the target's scale range
to the experimenter to the nearest 10 meters.

Procedure

Twenty-four male experimental subjects were obtained from the
training battalions at Fort Bliss, Texas. All observers possessed

at least 20-20 far acuity as determined by a B&L Orthorater. Each observer received 10 practice and 50 criterion trials for each speed value. Twenty-five of the trials for each speed trial for each speed were incoming while 25 were outgoing. Because adjustment of the equipment to different speeds proved time consuming, it was not possible to provide randomization of speeds from trial to trial. Therefore, the observers were presented with one speed per day as a block of 50 trials. Thus, three days were required for each observer to receive all stimuli. The order in which the observers received the blocks of trials was randomized. Due to administrative difficulties, complete data were obtained on only six observers.

Results

Table 1 gives the means and standard deviations in meters for the three speeds and two directions of movement. The magnitude of

Insert Table 1 About Here

the errors is similar to those reported by McClusky (1971) with observation under incoming conditions being considerably more accurate than under outgoing conditions. The data were then subjected to an Analysis of Variance summarized in Table 2. This analysis revealed that the main effect of direction of movement was statistically significant. However, varying target speed failed to produce any significant differences.

Insert Table 2 About Here

Discussion

This experiment failed to confirm the hypothesis of reduced error with reduced speed. The results of the present study cannot be generalized to situations with stimuli moving at different speeds or exhibiting other than radial motion. It is possible, therefore, that by further lowering the range of speeds, the increased decision time might result in more accurate judgments.

REFERENCES

McClusky, M. R. *Studies on Reduced Scale Ranging Training With a Simple Range Finder*. HumRRO Technical Report 17-24, December 1971.

McClusky, M. R., Wright, A. D., and Frederickson, E. W. *Studies on Training Ground Observers to Estimate Range to Aerial Targets*. HumRRO Technical Report 68-5, May 1968.

Footnote

Table 1

Means and Deviations For the

Three Speeds and Two Directions

	INCOMING			OUTGOING		
	200	300	400	200	300	400
X̄	1527.93	1540.33	1423.53	1300.30	1222.13	1238.00
σ	141.33	254.90	99.75	78.81	94.16	105.61

Table 2

Analysis of Variance of Speed vs. Direction

Source	SS	df	MS	F	p
Total	1,366,499.44	35			
S's	482,311.39	5			
A (I vs. O)	534,653.41	1	534,653.41	32.0	<.005
B (Speed)	42,176.89	2	21,088.44	2.76	
A × B	27,633.32	2	13,816.76	1.15	
Error A	83,529.50	5	16,705.90		
Error B	76,314.27	10	7,631.43		
Error A × B	119,880.46	10	11,988.05		

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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