word length; in the second, nonfluency, initial sound, and word length. In each analysis, the only significant relationship was between information and word length (respectively: $F = 19.59$, d.f. $= 2/126$, $P < .001$; $F = 19.93$, d.f. $= 2/132$, $P < .001$).

In order to investigate directly the relationship between word length and nonfluency, another sample of 144 words was selected from the original transcripts, stratified according to initial sound, nonfluency, and sentence position. A three-way analysis of variance showed that word length, as the dependent variable, was significantly related to initial sound and to nonfluency (respectively: $F = 34.11$, d.f. $= 1/132$, $P < .001$; $F = 9.75$, d.f. $= 1/132$, $P < .01$). There were no significant interactions in any of the above analyses.

To examine the reading of normal speakers, tape recordings were made of 207 male undergraduates reading Quarrington's 95-word passage, for which word information values were already available. The number of nonfluencies for each word were categorized into 0 to 1, 2 to 4, and 5 or more, and these three groups were matched on word length by discarding words from two of them. Information value was dichotomized at the median for the words utilized. Chi-square analysis showed that nonfluency and information were positively related ($\chi^2 = 9.95$, d.f. $= 2$, $P < .01$). A t-test comparing fluent and nonfluent words showed that long words were uttered nonfluently significantly more often than short words ($t = 2.68$, d.f. $= 93$, $P < .01$).

The spontaneous speech of 35 normal speakers was then recorded and transcribed, the topic this time being the Vietnam war. From the first 300 words of the transcriptions, 45 fluent and 45 nonfluent words were selected, matched for exact sentence position. Information values of these 90 words were determined as above from the guesses of 165 undergraduates. A two-way analysis of variance showed that information, as the dependent variable, was related neither to nonfluency nor to sentence position ($P > .10$ in each case). A t-test between the 45 fluent and the 45 nonfluent words showed that word length was unrelated to nonfluency ($t < 1$). Another t-test between long and short words (dichotomized as close as possible to the median length of the 90 words) showed a positive relationship between word length and information value ($t = 3.37$, d.f. $= 88$, $P < .01$). I should point out that word length was not included in the main analysis of this particular study because the study was conducted before the importance of word length was realized. However, the meaning of the results does not appear to be affected by this omission.

Existence of a nonfluency versus word length (but not a nonfluency versus information) relationship in both the reading and spontaneous speech of stutterers suggests the rather unsurprising formulation that the likelihood of a stutterer stuttering on any given word depends not on how much information it conveys but on how much speech production is required to say the word. The fact that long words are shown to carry more information than short words is also unsurprising, but is another matter entirely. This formulation also applies in part to the reading of normal speakers. However, no such relationship applies to normal spontaneous speech: the most to be demonstrated here is that, like the other situations, longer words carry more information than shorter words. The results also suggest that we should question theories of stuttering which postulate that nonfluencies in stuttering are determined by the same factors as in normal speech.

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Stereoscopic and Resolution Acuity with Various Fields of View

Abstract. *Progressively restricting the field of view—without, however, obstructing the binocular visibility of the targets—does not affect resolution acuity, but stereoacuity is increasingly degraded.*

Although there are many similarities in the behavior of resolution and stereoscopic acuity as a function of physical conditions, recent studies of visual processes under water have revealed a significant difference. In clear water, resolution acuity is at least as good as it is in air (*1*), but stereoacuity suffers a marked deterioration (*2*).

What causes this difference? The most notable characteristic of underwater viewing is, perhaps, that the field of view is generally hazy and relatively undefined, with few clearly visible objects. It begins to approach a "ganzfeld," the psychological term for an unstructured, homogeneous field of view. The distorting effects of the ganzfeld have been pointed out for many visual functions (*3*), but not, apparently, for any form of acuity, no doubt because the presence of a distinct target is, strictly speaking, incompatible with the idea of a ganzfeld.

Acuity, of course, is best in the fovea and deteriorates very rapidly as the target is imaged farther and farther in the periphery. For well-illuminated tar-

Table 1. Resolution acuity in minutes of visual angle with fields of view of different extent.

Observer	Field of view			
	Unrestricted	45°	7.5°	3.8°
SL	0.588 ± .08	0.528 ± .06	0.660 ± .04	0.528 ± .10
JW	.576 ± .05	.408 ± .09	.624 ± .15	.564 ± .02
FD	.624 ± .02	.576 ± .05	.588 ± .04	.624 ± .03
CL	1.026 ± .04	.840 ± .06	.858 ± .06	.726 ± .02
JL	0.774 ± .06	.828 ± .10	.708 ± .07	.858 ± .03
HM	.858 ± .12	.840 ± .06	.840 ± .07	.840 ± .03
AR	.942 ± .09	.960 ± .11	.540 ± .15	.972 ± .07
RE	.726 ± .09	.708 ± .02	.660 ± .04	.756 ± .07
Mean	.764 ± .07	.711 ± .07	.685 ± .08	.734 ± .05

Table 2. Stereoacuity (η) in seconds of arc with fields of view of different extent.*

Observer	Field of view			
	Unrestricted	45°	7.5°	3.8°
SL	1.4 ± 4.2	5.5 ± 8.3	6.9 ± 8.3	6.9 ± 8.3
JW	4.2 ± 4.2	5.5 ± 3.6	5.5 ± 2.8	5.5 ± 8.3
FD	6.1 ± 1.4	17.2 ± 4.2	12.5 ± 4.2	36.0 ± 8.3
CL	6.9 ± 2.8	6.9 ± 24.9	49.9 ± 12.5	130.2 ± 44.3
JL	6.9 ± 6.9	6.9 ± 8.3	13.9 ± 2.8	16.6 ± 5.5
HM	33.2 ± 6.9	34.6 ± 4.2	24.9 ± 13.9	131.6 ± 21.6
AR	8.9 ± 3.6	6.9 ± 9.7	13.9 ± 48.5	27.7 ± 60.9
RE	0.6 ± 4.7	1.4 ± 6.4	13.9 ± 7.8	13.8 ± 5.5
Mean	8.6 ± 7.2	10.5 ± 11.1	17.7 ± 12.5	46.0 ± 20.5

* Without regard to direction of error.

gets, when the target is only about 10° from the fovea acuity is only one-tenth as good as foveal acuity (*4*). From this it might be supposed that the peripheral field of vision plays little part in determining the acuity for a foveal target. It has long been known, however, that target-detection is impaired in an empty field (*5*), and other functions which are thought to be basically foveal in nature, such as reading, are reported to suffer in the absence of peripheral cues (*6*).

This study reports the effects on foveal stereo- and resolution acuity of the loss of increasing amounts of the peripheral field of view—conditions under which, it should be emphasized, the targets always remained unobstructed for both eyes.

Stereoacuity was measured with a three-rod Howard-Dolman apparatus. The dark-gray face-plate of the apparatus was 5.36 m from the subject and subtended visual angles of 3.8° by 4.8°. The rods, subtending a 0.06° visual angle and separated by 0.78°, were visible through a 1.4° by 3.8° window in the face-plate. The two outer rods were fixed in position at 5.59 m from the subject; the middle rod was movable.

Resolution acuity was measured with a series of grating targets, reproduced photographically in various sizes and presented in the window of the stereo apparatus. Both sets of thresholds were measured with binocular vision by using the method of constant stimuli. The subject was given as much time as he wished to reach a judgment.

Eight staff members of the laboratory viewed under four conditions (assigned in counterbalanced order): unrestricted field of view, 45°, 7.5°, and 3.8° field of view. The field was restricted by placing, 15.24 cm in front of the subject's eyes, a sheet of curved white bainbridge board with two circular holes of appropriate size; one hole was fixed, and the other could be moved horizontally to adjust for differences in interpupillary distance. The narrow room contained various pieces of equipment along the walls, and as the field of view was enlarged, more of this usual scenery was visible.

The white background of the stereoapparatus was illuminated to 1.0 mlam. The unpainted wallboard in back of it was 0.6 mlam. The brightness and color of the bainbridge board were matched to this wall by positioning a tungsten light over the subject's head. Thus change in the field of view did not entail much change in illumination.

Table 1 shows that mean resolution acuity remained essentially unchanged as the field of view was varied. There were no consistent trends either for a given subject or between subjects. There were also only minor differences in the standard deviations; the smallest field of view yielded the greatest precision. It is clear that reduction of field size was not harmful.

The results for stereoacuity, shown in Table 2, are quite different. Both the mean thresholds and their standard deviations increased with decreasing field of view. Every subject's performance worsened, although the deterioration was greater for those with relatively poor thresholds under the unrestricted condition. The deterioration was particularly marked when the restriction of the field of view was very great, but there was a measurable reduction even when the field of view was as large as 45°. Thus, peripheral visual cues are necessary to maintain stereoacuity but are not necessary for resolution acuity, at least when there are no restrictions on exposure time. That is, peripheral cues are needed for the task which requires both eyes but not the task whose results with both eyes are very little better than those with the best eye alone.

These results do not indicate, however, which visual functions are being degraded by the loss of the peripheral cues. One possibility is that there is a loss in the ability to maintain binocular fixation within the limits of Panum's fusional areas. It is well known that the eyes are constantly in motion (*7*). The two eyes of a given individual reportedly exhibit drift patterns with markedly different directional nonuniformities (*8*). Proprioceptive cues apparently do not effectively signal these small movements (*9*), and the eyes cannot be kept precisely on target (*10*). Fender and Julesz (*11*) have found that very small disparities, in conjunction with brief occlusions, are enough to produce loss of fusion. It is conceivable that, in the absence of peripheral cues, these involuntary drifts become large enough to degrade stereoacuity.

On a different level, Kaufman (*12*) has argued that stereopsis occurs when correlated stimuli are out of phase with respect to a reference system composed of another set of correlated stimuli. This suggests that stereopsis would be degraded by a decrease in the amount of stimuli available for correlation, which presumably occurs when the field of view is restricted.

In any event, for whatever reason, peripheral cues are evidently important for stereoacuity, and the present results support the notion that it deteriorates under water because of the relative lack of stimulation in the periphery of the visual field.

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