THE WHITEOUT PHENOMENON

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A review of the current status of research on the Whiteout Phenomenon shows an almost total lack of progress toward a solution of the problem. An amazingly large literature exists on the subject. This has been ably summarized by George Barker of the Army's Fort Knox Laboratory. Unfortunately, even though the phenomenon presents man with a specific type of visual problem, it seems that all the authors of publications on whiteout are not talking about the same thing. It is evident that many of the writers have never themselves encountered it and that frequently they are relying on rather inept accounts of untrained observers.

The effects of whiteout have been attributed to a "hazy atmosphere" which leads to blurred vision in which "victims maintain their optic senses but in a confused way". Attempts have been made to associate whiteout with snow blindness. Blowing snow, fog, empty visual fields, ice fog, and many other environmental features have confounded the issue. None of these conditions is required. Actually, whiteout can occur in a crystal clear atmosphere with ample, comfortable light and with the visual field filled with trees, telephone poles, quonset huts, or oil drums.

In reality, whiteout is a very simple phenomenon due to easily understood causes and having only one direct effect: the loss of depth perception. This results in quite unexpected and sometimes disastrous consequences. One may step off a high cliff, taxi into a snow bank, drive or walk into a ditch, fly into the ground short of the runway, dig a wing-tip into the snow, or stumble over a bump on the ground. Afoot, the sensation is that of groping down a staircase in the dark and finding a step unexpectedly missing. The only recourse is to shuffle along at a maddeningly slow pace. In the air, the only safe procedure is IFR, making landing difficult, if not impossible.

Only two conditions are necessary for the production of whiteout:

(1) Diffuse shadowless illumination
(2) A uniformly mono-colored or white surface

In polar regions these conditions occur frequently. Large unbroken expanses of snow are illuminated by a sky overcast with dense, low stratus clouds. In combination, these blot out all traces of surface texture and shadows. Since objects are differentiated from their surroundings by contrasts in color and texture and by their shadows, this tends to merge bumps and hollows and snow covered objects into a flattened, white background, with a complete loss of all modeling.

In front of this homogeneous background, objects of sharply contrasting color such as posts, oil drums, airplanes, cars appear to float at an undetermined and indeterminable distance. Those who have not been exposed to whiteout are often

frankly skeptical about the inability of those who have experienced it to estimate distances under these conditions. In the normal environment there are so many direct and indirect clues to depth that it is hard to understand how one who can see clearly can still fail to gauge distances accurately.

Let us examine these clues. First, there are the primary ones -- those which result directly and without the intervention of thought or logic in a "feeling" of depth. These are the muscle tensions exerted in accommodation of the lenses and convergence of the eyes and the sensations brought about, in some poorly understood way, by the disparity of the images on the two retinas. These sensory data, which, incidentally, are unaffected by whiteout, can be utilized for the formation of precise estimates of distance but only within a very limited radius. Thus, a pilot cannot be trusted to taxi through a parking area without a "wing walker" or a "Follow Me" jeep.

The remaining clues to depth, and they are of the greatest importance in everyday life, are secondary. That is, the mental "readout" is not directly in terms of distance but of appearance relative to some standard. While the impression of spatial separation of objects from the observer may seem to be intuitive, quantitative estimation of the distance involves a definite mental, although frequently subconscious, act of comparison. These secondary clues fall into two categories: aerial and linear perspective.

The term aerial perspective is used by artists to refer to the lessening of color contrast and the progressive loss of fine detail which occur as an object recedes into the distance through air which is never completely transparent. It plays an important part in creating the illusion of distance in pictures, but, because the clarity of the air is so variable from place to place and from time to time, it is of little value in forming quantitative judgments. In fact, it may easily contribute to the formation of misleading impressions. This is especially true under whiteout conditions; with a featureless white background, it is impossible to gauge the optical density of the air. It may be full of blowing snow or fog or it may be perfectly clear.

Linear perspective, or the progressive reduction in apparent size or more precisely, visual angle, with increasing distance is undoubtedly the most important of all clues to distance beyond the binocular range. This obeys strict mathematical laws which were known to Euclid and which form the basis for one of the accepted techniques for measuring moderate distances in surveying. All that one has to do to determine the exact distance of an object of known size is to estimate its apparent size. This sounds simple and it can be done easily and precisely with instruments. Probably not one person in a thousand knows that it cannot be done by the unaided human eye -- perhaps it would be better to say, by the unaided human mind. What is involved is the measurement of an image on the retina and it has been demonstrated again and again (remember all the optical illusions you have seen) that the eye has no absolute sense of size. If, and only if, one can see the yardstick and the object at the same time, and provided, moreover, that the yardstick is at a known distance, can it be done. Thus, the artist uses his thumb or a pencil held at arm's length in the same manner that the surveyor uses precisely calibrated stadia hairs in the plane of focus of his transit. Even Euclid knew that objects appeared to be farther away than his rules predicted.

How is it then that we get along so well in the familiar world? Normally, there is a continuous succession of familiar objects starting from somewhere well within the range of binocular depth perception (where primary clues are effective) and extending out to and beyond the object of attention. Both foreground and background combine to furnish many reliable clues to the distance of any object -- even of objects of unknown size. (Up to this point, I have stressed background rather than foreground but you must remember that part of the general background becomes the foreground of any object at any distance.) But, and this is the crux of the matter, this entire visual continuum is erased by white-out. This is such an unfamiliar situation that all vestiges of depth perception may be lost without one's even being aware of impairment. Naturally, this frequently leads to extreme confusion and even disorientation.

At first thought, the harnessing of motion parallax might seem to provide a solution. Motion parallax normally aids in depth perception through the relative apparent motion of fixed objects in a moving visual field. However, one must realize that the apparent speed of relative motion is dependent upon perceived spacing and this is in turn dependent upon linear perspective. As I have just told you, this is unreliable. It is possible, nevertheless, that the changing angles in a moving field may introduce a new and useful element. If so, this effect would be especially valuable in landing an aircraft, provided an adequate number of points were present in the visual field.

The Air Forces' concern about whiteout is in relation to flying safety. In the last 7 years, 4 aircraft accidents in the Alaskan Air Command are positively attributable to the phenomenon. The number of other accidents in which we can only speculate about the causes but in which whiteout is a definite possibility is undoubtedly high. Whiteout is actually only a problem to the pilot in landing, take-off, or taxiing. However, low flying, at altitudes less than 1000 feet above the terrain, is particularly hazardous under these conditions and has resulted in numerous wrecks which are strewn across Alaska.

Ground operations are impaired, whether they involve walking or the use of vehicles. On an overcast morning following a new snow, the roadsides are littered with vehicles, frequently including the snow removal machinery. Often roads are closed -- not because of snow depth, but because of whiteout. Incidently, the whiteout need not be total. One can easily blunder off the shoulder of a road running through a well forested and highly visible area, simply because of inability to distinguish between the shoulder and the adjoining ditch.

Solutions may result from two possible avenues of attack, physical and psychological. That is to say that we can either try to eliminate the phenomenon or learn to live with it. Physically, the point in question is whether the quality of light reflected from snow covered objects may vary in some subtle way with the angle presented by the surface or from the incident sky light so that contrast might be enhanced by the use of appropriate filters. Many trials of colored glasses have been made over the years. Unfortunately, the evaluation has been subjective. As a result, some writers have made the topic controversial through their militant support of goggles of some particular color. Polarizing goggles have also been suggested. Physical data on the character of light in a whiteout are needed to provide

a basis for the use of filters. Dr. Rose of the School of Aviation Medicine made a few observations at Operation Deepfreeze but had so little opportunity to observe the phenomenon that he does not rely on his spectrographic data. We intend to use his spectrographic camera this winter where we have frequent opportunity to make observations.

A scheme which would unquestionably work would be the use of intense, directional, artificial light. Whenever the level of natural illumination is not too high, headlights can create adequate shadows and contrast. However, this is not a solution of general value because of its impracticality during normal daylight hours.

The use of smoke bombs on landing strips has been suggested, particularly if there is a little wind to move the smoke across the snow in such a fashion as to create stained "shadows". Several bombs might be effective in an unprepared, emergency operation. However, many objects are required in the visual field to provide adequate clues as to depth. According to Dr. Rose, some 250 to 500 points are required for good motion parallax. Repetition of crossbars of fixed size to form a dense pattern is very useful, although bars at every 60 or 120 feet would be far more helpful than the conventional 500 foot spacing.

The training of military pilots to cope with the whiteout phenomenon presents difficulties. Whiteout is not always available; hence, the setting up of a training program would be rather haphazard. That experience in flying in whiteout is useful is evidenced by the ability of bush pilots to operate with relative impunity under these conditions.

The immediate effort of the Arctic Aeromedical Laboratory is in the collection of spectrographic data on the available light to answer once and for all the practicability of filtering goggles. The long range program includes the evaluation of training and of visual aids.