LIGHTING AND HEALTH HAZARDS

David G. Cogan, M.D.

Dr. Cogan: I am the "no expert" on the panel, merely an ophthalmologist who has had some tangential contact with illumination but insufficient to give me much authority in the subject. Moreover, I should say that although I represent here the National Eye Institute, nothing I have to say necessarily reflects the opinion of that Institute. In fact, I have not heard the subject of illumination discussed in Bethesda, Md.

My presentation can be summarized in a single sentence. No organic disease of the eyes results from low illumination. Of the various ophthalmic diseases which we are called upon to treat (glaucoma, cataracts, retinal degeneration, etc.) none are influenced by use of the eyes in so-called poor illumination. Miners' nystagmus, which is often cited as an exception, is a controversial subject in which many factors other than lighting are involved, and has no recognized counterpart in other occupations.

Of course, my comments have to do with the possibility of disease and do not bear on the esthetics of lighting, the quality of lighting, or the efficiency of work functions with lighting. I would judge, from this morning's discussion, that you would agree with me that low levels of illumination do not cause any disease state in the eyes but the public has the opposite opinion. The public has the opinion that low levels of illumination is doing harm to their eyes and to their babies' eyes. This impression has been fostered by the commercial interests in the lighting industry.

Some 35 years ago I took issue with the rampant commercialism and, being charged with writing an annual review article on ophthalmology, I emphasized the obligation of the medical profession to reassure the public that no serious health hazards were involved in "poor illumination." It is probably fair to say that this represents almost unanimous ophthalmological consensus but few ophthalmologists have been sufficiently concerned to carry the message to the public or even to the general medical profession.

This then is my comment on Point 1 of the question posed by Chairman Heins in his initial charge to us. There is no substantial evidence indicating eye damage, permanent impairment of visual functions, or eye disease from working under low levels of illumination.

Another, and related, question which has been raised, bears on the nature of "eyestrain." In the minds of most persons this suggests something akin to a muscle strain in one's limbs and is a definite concept. But ophthalmologists have difficulty in defining eyestrain in any such definite terms. Rather it is an effort syndrome and therefore more psychological than physical in which a visual task is performed under difficult circumstances. Headache, irritability, nausea and other symptoms may be brought on by continued visual tasks which are rendered difficult by refractive errors, ocular motor aberrations, insufficient illumination, or glareful conditions just as they may be brought on by persistent listening to music with the hardships of low levels of audition or in competition with distracting noises. Yet in the latter case it would be ridiculous to talk about ear strain with the idea that we were doing organic harm to the ears. The basis for eyestrain is similarly tenuous. It would be better if the word eyestrain were deleted from our vocabulary.

Dr. Blackwell opted for deletion of some word in this morning's presentation. What was that word?

Dr. Blackwell: "Unnecessary."

Dr. Cogan: I would opt for deletion of "eyestrain" since it has such ambiguous implications. Perhaps we should use the professional term, asthenopia, which does not suggest an analogy with strain of a skeletal muscle.

DISCUSSION

Mr. Caplan: I am concerned about your comparing this to hearing and noise where you definitely have two kinds of a strain: a permanent strain, such as a permanent threshold shift, and a temporary strain which is a reversible type of reaction. Are you suggesting that there is no such thing as a temporary threshold of seeing?
Dr. Cogan: Right.
Mr. Caplan: Are you suggesting that there is no temporary thing that goes back to full use?
Dr. Cogan: No more than there is for hearing, no.
Mr. Caplan: There is for hearing.
Dr. Cogan: Low levels of hearing?
Mr. Caplan: No, for high levels, (of noise).
Dr. Cogan: I would like to talk about high levels later. High levels of lighting certainly can cause damage to the eyes. I would like to come back to this in a minute.
Mr. Caplan: Okay, but I am wondering whether you have a loss of ability to see from the low level, temporary as it may be.
Dr. Cogan: Right, I think you do. At low levels you have trouble seeing. If you try to do anything which is a difficult task, you are going to end up with a headache and other symptoms. But that is not damaging your eyes.
Mr. Caplan: The fact that it is temporary does not necessarily mean that it is not disease, because disease may be permanent or temporary. You may have a headache, or other symptom, in other industrial exposures. For example, it is not acceptable to create a situation such as carbon monoxide exposures, that causes headache, which is completely reversible.
Dr. Cogan: The point I am trying to get across is that there is no physical damage to the eye as a result of this, any more than working too hard in the garden.
Dr. Halldane: That is physiological, no behavioral, or anything like this. You are only speaking of the physiological.
Dr. Mead: Well, primarily, sir, you are talking about input to the eyes, the seeing, the optical part. The fact that the eye, if it works under difficult conditions, you do get muscular strain from the muscles in the head, neck, back, and so on. At the end of a hard day's work, you develop strain, muscle strain in both striated and smooth muscles.
Dr. Cogan: I had not thought of headache in this connection. What muscle goes into spasm?
Dr. Mead: Neck muscles, back muscles, if you work hard enough while seeing.
Dr. Cogan: Is that so?
Dr. Mead: Yes.
Dr. Cogan: I personally get symptoms, but I do not get back strain. Maybe in this case it ought to be called "back strain" rather than "eyestrain."
Dr. Halldane: I think what we are coming at is the distinction between "stress" and "strain" in the behavioral sense. Generally, we speak about "stress" as the environmental distress or the exterior physical thing that produces the strain in the system itself. Now, generally, we can measure the stress or the stressor, but we have no availability of measuring the strain in what you are speaking of. I think this is the difficulty that you are getting at i.e., what is measurable. And so your objection to the word "strain" is legitimate, because we cannot measure it, and, therefore, it is not very constructive. Now, if we talk about the stresses of an environment and why it impedes behavior or people's physiological responses, you use the word "impeding." And then, if it is nonreversible, you talk about "impairing." Now, I think we get out of that trouble. All right? So we can talk about impeding physiological responses to the extent of impairment where it does not return to its original condition. This might get over that semantic hangup that these sort of discussions always tend to get into.
Dr. Cogan: Yes, I do not know whether it is worth pursuing too much, because it is a matter of semantics. What I am objecting to is the public's interpretation that you are doing something organically harmful to the eye from low illumination. That is what I am saying "no" to. That is what the public identifies with the word "eyestrain."
Mr. Nelson: Yes, there is also the fact that the question on impairment as it is brought back here, industrial impairment, daily headaches, et cetera, that are unacceptable on a job. Such things built in a job might be unacceptable in a clerical job, also. But the feedback I get are terms that I would call "discomfort," "annoyance," "personal dislike" and so on. What I am concerned with is passive impairment or reversible impairment which is probably a broader spectrum range than, actually, perma-

nent impairment; and it is being used and expressed as one point, or one place. And, if we move into that, again, I am very anxious that we quantify it somehow.

Dr. Blackwell: May I make a small point? I agree with you thoroughly. I have not been aggressive enough to do it for the last few minutes. I agree with you thoroughly about your main point, which is that there is no anatomical change with low levels of light. I wanted to make the point that, in your analogy of the other sensory systems, if one is impoverished for information, there may be a claim of stress which may produce impairment; but there is a very obvious and important difference between the ears, the nose and the eyes. And that is that the eyes have the well-known ocular motor systems which are servo-driven by information and that the ears do not. Our ears do not rotate. Our nose does not change its properties in order to smell; it is a passive detector. Now, the eyes are not. I hope to simply remind you, if some of you are gone by the time I have a chance to talk this afternoon, that I am going to be talking about the ocular motor systems, which, in my opinion, are clearly implicated as the reason for symptoms. When peoples' ocular motor systems do not operate up to their ultimate precision because of low levels of visibility, which can be produced by low levels of light under some circumstances, this corresponds to symptoms. And I would have to object—and you agree with me, of course—that the eyes are not like the nose or the ears in this rather important respect. I am speaking of accommodation. I am speaking of binocular fusion, of conjunctive eye movements. It is the eye muscles that are involved here and I want to bring this out later this afternoon.

Dr. Cogan: Could I say something else, though, in another tack? The reverse, it seems to me, is very relevant to our deliberations. It is not on the program, but it has been suggested several times that excess light is potentially damaging to the eye. We have long known, of course, from cases of eclipse blindness, that if you get enough light in the eyes, you produce retinal degeneration. We have also observed, occasionally, sun gazers who damage their eyes by looking at the sun. I have recently examined a prisoner of the famed Charles Street Jail in Boston who looked at the sun with one eye for two hours and the other eye for four hours and ended up with typical macular degeneration in both eyes.

But viewing of the eclipse or the sun—and the same holds true for exposure to the flash of an atomic bomb explosion or to a laser beam—involved such unnatural and intense exposures that we did not consider them in the sense of occupational hazards. Then, a few years ago, Werner Noell in Buffalo reported the blinding of mice by continuous exposure to fluorescent lights. This was abundantly confirmed by Dr. Toichiro Kuwabara. Dr. Weale referred to similar deleterious effects on other animals and Dr. Ephram Friedman and his collaborators have shown comparable effects in human beings after prolonged exposure to the bright lights of indirect ophthalmoscopy.

We do not know whether or not such exposure to light can cause macular or other retinal degeneration in man but that possibility is being explored by Dr. Mark Tso and his collaborators at the present time.

In this connection it may be of some interest to point out that the retina is transparent and does not therefore absorb light that is focused on it. But, immediately behind the retina is the pigment epithelium which is highly absorptive of visible and infrared radiation. The heat generated must be efficiently dissipated and for this we have a very vascular membrane, the choroid, which presumably acts as a radiator.

But, with the slowing of circulation with age, this heat radiator may become less efficient and it is not inconceivable that the retinal degeneration which occur predominantly with age, such as macular degeneration, may result from exposures to light that are harmless in younger persons.

Thus in reply to our chairman's request for suggested lines of future research I would propose the study of the harmful effects of excessive light instead of pursuing the chimera of harm from insufficient illumination.

Mr. Crouch: I have had occasion to examine Noell's work and Kuwabara's work. I have analyzed it and found that they apparently made some mismeasurements, physical measurements of the intensity of the light; and they could not possibly have gotten the levels that they got. I explained this in rebuttal to your article in the *Sight Saving Review*. And then we had Dr. Noell at a seminar two years ago last March and he told us that human beings have a mechanism which protects them, which

the rats and mice do not. So that this could not be extrapolated from rats and mice to human beings. Of course, we know that the rats and mice have primarily rods and human beings have cones. They are a nocturnal animal. And the tests that were run were continuous exposure with no relief to the rats. They were surrounded by a bank of fluorescent lamps clear down to the horizon; they could not get away from it. And they were kept in continuous exposure until they burned out their retinas. So, actually, there was a non-uniform damage. It appears that what was happening was the projection of images of the tubes upon the retinal surfaces, because the eye acts as an imaging media. And so these rats, who could not get away from this thing, were registering images. The rats and mice tend to freeze under an unnatural environment. So they were projecting these images in a way that a certain part of the retina was more damaged than others.

Now, Dr. Tso has repeated the same kind of an error, and I notice it is picked up by others recently. Bruce Boyer of the Environmental Protection Agency, with whom I have been in correspondence, was using this in the Washington *Star News* as an answer to the editorials of employees of the General Services Administration. He sent me all of the data, and there is a *J.A.M.A.,* March 12th, 1973, Medical News, which infers that, according to the title, "Long, Well-Lit Lives May Lead to Eye Damage."

> "Is macular degeneration the price we pay for living longer in better light? .
> No one can say for sure, but Mark O. M. Tso, M.D., suggests physicians should at least consider the possibility that some forms of macular degeneration may be related to the cumulative effects of a well-lighted lifetime, including its hours devoted to television watching.
> Dr. Tso, a Research Associate of the Armed Forces Institute of Pathology and Assistant Research Professor of Ophthalmology, George Washington University Medical Center, told a Research To Prevent Blindness (RPB) Science Writers' Seminar in Los Angeles about work with twenty-four monkeys."

Now, Dr. Boyer was kind enough to send me the original paper, published in *The American Journal of Ophthalmology,* May, 1972; and what Dr. Tso did, was to use an American Optical Company indirect ophthalmoscope with a 20+ lens and put it continuously on the rhesus monkeys for one hour. As a result, he then showed pictures of macular degeneration. I felt he was committing the same error as Kuwabara and some of the others, because what was happening was a projection of the image of the source was being put directly on the retina. So I wrote him a letter as a result of Dr. Fry's suggestion and asked him if he would tell me the brightness of the image that was projected on the retina that caused this, and whether he measured, by a photoelectric cell, the beam only. Because the error that occurs in this, they take a big enough cell, and then they average it. They average a high intensity over enough area and they get a low level response from the photoelectric equipment. And so I wanted to know what the density was in the image itself and then also the beam, because it was twenty to twenty-five centimeters from the cornea of the eye that it was directed.

And it says here that the focused "maculas of nineteen young adult monkeys were exposed to the light of an indirect ophthalmoscope with a 20+ lens continuously . . ." Then it says they focused this: "The filament of the electric bulb was focused on the fovea. The central column of bright light from the ophthalmoscope was completely within the pupillary zone. The position of the ophthalmoscope was verified by direct observation every five minutes or less to make sure that there was no alteration in the area of exposure."

Now, I have taken it upon myself to write to Dr. Tso and he said, "I don't know. We don't have instruments here to measure it." He also said, "I think this is a very important issue. Would you please find out what it is. I therefore urge you to actively pursue in this direction to remeasure the illumination of the filaments as well as the whole profile of the beam."

So I got in touch with the American Optical Company and they responded very nicely, and said, "I believe that he probably used the old AO Model 11260 indirect ophthalmoscope with a less efficient heat filter. We made some measurements, and that instrument with a +14 diameter lens was 7.55 volts with a tungsten bulb. Our results were: total radiance, 4.4 watts per steradian per square centimeter; and the visible radiance was 0.88 watts per steradian per square centimeter." Of course, this shows a great infrared component with very

little visible. But, on the other hand, I have found out that if you project the visible image on the film and put it sharp on the retina, that this is 700,000 footlamberts projected on the macula. This is fifteen times white snow under five thousand footcandles. We are recommending seventy footlamberts and this is seven hundred thousand.

Dr. Blackwell: Even without the infrared.

Mr. Crouch: That is right, even without the infrared. So what is happening is these medical researchers are not measuring what they are getting. So, therefore, we cannot use the material as related to what is happening to ordinary light.

Dr. Weale: I think I can throw a little light on this, if I may coin a phrase. I have done some experiments on my own eye which relate pretty accurately to what Dr. Cogan has told us about Noell's experiments. I think we have to remember, in connection with what Mr. Crouch has just mentioned, that Noell went out of his way to show that it is only light which is absorbed in the rods which produces the sort of degeneration he reported. Therefore, infrared can be effectively ignored in this particular conference. It is only light which is absorbed which has the actual spectrum of rhodopsin that matters. I am quoting from memory—I was not prepared for this—but I seem to remember that Noell also says that, in his experiments, about seventy-five percent of the rhodopsin was bleached. This gives us a measure of the intensity in physiological terms. When I bleached the rhodopsin and cone pigments in my own eye, I bleached them to completion and I compared the intensity of a summer sky in order to arrive at a biologically meaningful value with the sort of intensity that is needed to produce complete bleaching. We shall not be worried about focusing or filaments or anything like this. I will tell you that, when my pupil is fully dilated, and I view a London July sky—which was pretty bright at the time—for thirty seconds, I bleached about eight percent of everything that I can bleach using, for example, a Xenon arc with a heat absorbing filter. As Dr. Blackwell just said, the pupil was fully dilated, but, of course, I used it only for thirty seconds. If the pupil is not dilated, you can cut it down by a factor of ten, if you like.

Dr. Blackwell: Why not sixteen?

Dr. Weale: Well, we are discussing orders of magnitude. But the point that I want to make very strongly in support of what Dr. Cogan has told us, even if there is no linear relation, no linear reciprocity, there is a prima facie chance, we will put it no higher, a prima facie chance that senile macular degeneration—and I have never heard it said before today—could be linked to this sort of thing. You ask yourself, why are rods not affected? I think the answer may, on the face of it, be pretty obvious. We have shown that you need the same number of light quanta to bleach foveal cone pigments, and rod pigments. They are equally sensitive. To that extent, therefore, any physiological effect which may be attributed to one ought to be attributed to the other. But the rods are protected by the absorption of the crystalline lens to an extent which is not available to the cones. To a certain extent, there is macular pigment which will take care of the sort of radiation which would affect the rods. I think, therefore, that from this particular point of view—it is stretching things a little—the cones are particularly vulnerable and I would like to support Dr. Cogan very strongly in his suggestion that here is a field which certainly merits attention. One does not want to spread any alarm, but this is a thing which ought to be disproved pretty soon.

Dr. Blackwell: Would you not agree, both of you, from the accumulated knowledge from many laboratories that we can be certain that illuminance from an extended source, be it a sky or a light fixture, of two thousand footlamberts creates no normal problem. Taking your numbers, for example, the sky on a bright day and allowing for the change in pupil size, I would get a safety factor, surely, which says that two thousand footlamberts is no problem. Actually, the most sensitive experiments, not the ones you are reporting, were those of Sperling. Sperling was picking up changes that are so small you can see nothing at all histologically. But, in monkeys, he showed that there were long-term changes in the function of, let us say, one cone type, which made it perfectly clear that there was enough absorption to do something. Pressed for numbers, he comes out with numbers that make sense in terms of our experience with the out-of-doors world, which is that, truly, you have to be talking about ten, more likely twenty thousand footlamberts before there is trouble. Now, my point is the following: Luminaires might reach two thousand footlamberts as an absolute

maximum; surfaces in a room never do. You are talking about fifty footlamberts, not five hundred or five thousand. So, with all due respect to caution, what we would have to say, I think, is that there is positively no reason for concern about anything except luminaires and that is going rather far, because I think luminaires create no problem. The sky out-of-doors is much brighter than that. So, if you want to worry about degenerations, the poor farmer who works outside is the one you want to worry about, not the office worker—unless he wears sunglasses and most of them do not.

To summarize, I do not believe anybody really has any reason for concern under around twenty thousand footlamberts. I talked to your man Palmer; he agrees with this point. I talked to Sperling; he agrees with this point. Twenty thousand, somewhere around there, is the first point at which to be concerned. Nothing in an interior environment is of that high luminance. So I think, truly, this is a bit of a tempest in a teapot.

Dr. Riegel: Is that for continuous exposure?

Dr. Blackwell: Yes, right. Sperling exposed them for days.

Dr. Weale: We are concerned about years, are we not?

Dr. Blackwell: Not without breaks in the cycle. Who stares at a luminaire for twenty years of his life without shutting his eyes?

Dr. Halldane: This is a relevant topic, because you can get reflected luminaires in glass windows and things like that. It is very important, because you are getting greater contrasts if you take out lamps under conservation programs. You are intensifying some of the contrast problems and they are some of the proposed conservation programs by GSA.

Dr. Blackwell: Of course, if you bared the tubes to save light, then you would be doing the most dangerous thing.

Dr. Halldane: In some cases, this could occur, with lack of sufficient guidelines, in an energy conservation program. So we are trying to consider, in this symposium, these sorts of contingencies, surely. Now, the Australian and British codes have limitations on the luminances of lamps, which is a very vital thing to include in the American guidelines that may be developed. And this will answer, I think, the concern and problems that are being generated by people who are concerned with the glare problems of higher luminances in the visual field. This is not an irrelevant problem because it should be identified as a significant problem of lighting in future guidelines and particularly under conservation programs.

Mr. Crouch: In the United States, the IES also recommends limitations on the luminance of certain lamps. It is two hundred and fifty footlamberts for large areas, and, for smaller areas, it is larger. But it will never exceed about a thousand footlamberts.

Dr. Halldane: It is ten candela per inch square in the Australian standard.

Dr. Blackwell: That is fourteen hundred forty candles per square foot.

Dr. Cogan: Dr. Tso is interested in the practical effects of indirect ophthalmoscopy damage to the eye. So he exposed the eye for one hour, perhaps to see if ophthalmoscopy does damage the eyes.

Mr. Crouch: Well, he reports, too—and I read you the journal, *J.A.M.A.*, where he reports that this applies to light.

Dr. Cogan: Right.

Dr. Blackwell: He is the one who went beyond—

Mr. Crouch: He went on to extrapolate.

Dr. Cogan: : It is the indirect light that he is using; that is the one that he is interested in.

Mr. Crouch: Good lighting in the interiors, he goes on to that in the journal. Here it is: "Long, well-lit lives may lead to eye damage." And he tells the science writers, "the Research to Prevent Blindness (RPB) Science Writers' Seminar in Los Angeles about work with twenty-four rhesus monkeys."

Dr. Cogan: Was that not indirect ophthalmoscopy that he used?

Mr. Crouch: He said it applies to lighting, ordinary lighting.

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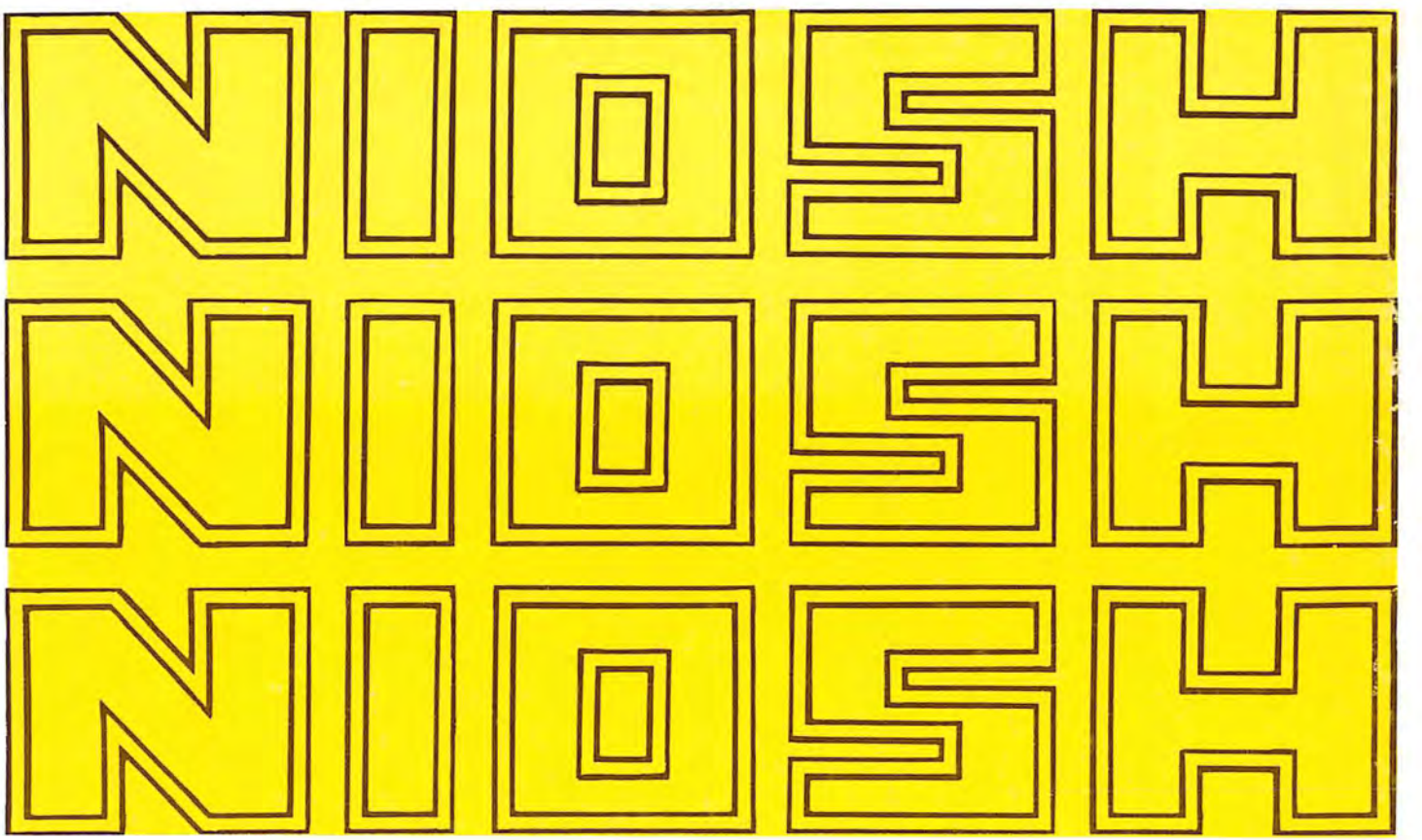

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