

Dr. Vinograd:

Don Beem sent this package to Dr. Berry. When I talked to Mr. Beem this morning, I was under the impression that he was also sending one to you. Since Dr. Berry wanted the original book, I was able to make a "quick copy" for you since I'm sure you'd want to see it ASAP. I didn't feel that I should call Mr. Beem to request another copy -- unless you want me to call. In any event, I hope this will do until we can get another copy.

Ruthie

TRANSCRIPT OF PROCEEDINGS

AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES

DISCUSSION SESSION

MEETING

OF THE

AD HOC COMMITTEE ON SKYLAB VESTIBULAR
EFFECTS

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9:00 A.M.,
Thursday,
October 25, 1973

Room B213,
NASA Headquarters
600 Independence Avenue, S.W.,
Washington, D. C.

DR. BORISON: I have had experience with labyrinthectomized cats, with the cerebellar of cats, and cats are very tractable. They recover nicely in the laboratory, and we have kept them for a long, long time. We use them for demonstrations to medical students, and studied riding with the eyes covered and uncovered, and cats certainly get sick in response to motion, and they also, of course, have marvelous otolith organs in the way they right in free fall and this type of thing.

If you are looking for an animal that has long engaged in a friendly relationship to man, the cat, it seems to me, would be a good candidate.

DR. GRAYBIEL: It is a tough animal.

DR. BORISON: Yes, it is tough.

DR. BERRY: Let us go back to this thing for a minute on the medication. I feel if we are going to use medication we ought to use it in some programmed manner, and you have got two choices. You can go a route that says that we either wait until we see if we have symptoms, and you check that out or you just pre-plan it, and you go ahead and medicate them for a given period of, say, three days and then see where you are at the end of that time.

We have discussed that because the crew is here this morning. My own personal feeling about that is that we ought to medicate them so that we do not get into this

2 1 situation that we had in the last mission. I do not think
2 we can afford that kind of thing on this mission, and I think
3 we ought to medicate them and prevent it, and I think that
4 means that you medicate them during normal waking hours, and
5 that would mean that you would have to give that medication
6 at least three times during that period.

7 Obviously, they are not having the symptoms while
8 they are asleep. There are individual differences, and I
9 think astronauts, as a group of people, are not pill takers.
10 If you ask an astronaut if he wants to take a pill he is
11 going to tell you no, in general. They will, and they have
12 become much more so in the interval, in the last couple of
13 years, I would say. We have had a lot more people as we got
14 to the point where we knew we had some things, and they
15 finally got convinced that you could take something and go
16 to sleep, and it was not going to kill you. And they really
17 learned that. They can take aspirin and things of that sort,
18 and they do that. For a while we got to where we were
19 fighting a battle with Lomotil. They all wanted to take
20 Lomotil, but that was for a reason that they wanted to take
21 it. We did not want them to take it, and so it was a reverse
22 kind of a situation. I think that my own feeling is that
23 we ought to go that route. If we do it I firmly agree with
24 Ash that you have got to run that test on the ground. I
25 would not want to give somebody that medication, either of

3 1 those medications for three days in flight without having
2 one of three days on the ground and knowing what happened to
3 them and them knowing that they could do that without any
4 effect on their performance which is equally as important
5 as my knowing it. It is more important that they know it.

6 So, that is my feeling. That is out on the table
7 for discussion, and I think we need to hear from all of you
8 who had had drug experience and find out what your feelings
9 are about that. It is probably more orderly to start down
10 the line though and do these in the order that we put the
11 questions together here because it makes some logical sense.

12 First, do we have any idea what the most probable
13 explanation of these things is? Do we really have some
14 feel? Does anybody have some view and want to express their
15 feelings about pathogenesis and etiology here and what we
16 are really dealing with? I do not think it is all as
17 clear-cut as maybe some of us are making it as we go along
18 here, and there are some unanswered questions, and that is
19 the wonderful thing about what we are finding out in Skylab.
20 So, I would sort of like it, and it is an open forum here,
21 and we have not heard much from the people down at the end
22 of the table. Why don't we start at the far end of the table
23 and work up here for a while.

24 DR. BRACKMANN: I am a clinician, and I have to
25 relate it in the things that I can relate it to.

4 1 DR. BERRY: Great. I think that is what is good
2 here. I think that is exactly right. We are going to have
3 different views here because of the different data, and that
4 is exactly why you are all here. We wanted different
5 backgrounds. We have some of you who are really pharmacological
6 ly oriented, some of you are clinically oriented, and some of
7 you are very laboratory oriented, and that is exactly what
8 we wanted. So, do not apologize for your view.

9 DR. BRACKMANN: I would compare the Skylab or any
10 astronaut, but particularly the Skylab astronaut to the
11 patient who suddenly loses a labyrinth or two labyrinths
12 occasionally, very occasionally, and they are incapacitated
13 and I think that the same thing happens in the Skylab or in
14 the zero gravity for the same reason. It is not as severe
15 because you are maintaining your semicircular canal function,
16 but you have got a sudden loss, at least a partial loss of
17 the gravity-dependent portion of the labyrinth, namely, the
18 otolith. I agree with Dr. Torok that probably what is
19 happening is that you are producing essentially a labyrinthine
20 storm and no matter what you do in regard to trying to
21 habituate to that is probably going to aggravate it, I would
22 guess, rather than produce any habituation.

23 If you take the patient who suddenly loses a
24 labyrinth and put her in bed or put him in bed lying still
25 with the eyes closed they do quite well, but if you try to

5 1 ambulate that patient they are very quickly vomiting and
2 falling and in a serious situation. So, I think that what is
3 happening is that you are suddenly losing a percentage of
4 the normal vestibular input, and I think that over the next
5 three or four days that the patient is compensating for that
6 at a central level. How that occurs I do not know, but I
7 think that the reason it did not occur in the earlier flights
8 was the limited mobility. You were essentially putting the
9 patient in bed, looking straight up with their head fixed,
10 and they were able to tolerate that. You get them moving
11 around in the bigger atmosphere, you are essentially walking
12 them around, and they then are not able to tolerate this
13 labyrinthine storm, and I think that is what is happening,
14 and for that reason I would certainly agree, Dr. Berry, with
15 your feeling that probably as little activity as possible
16 and probably some prophylactic drugs until this labyrinthine
17 storm is over.

18 DR. BERRY: Let me ask, you said that you feel you
19 are having some reset of the central nervous system probably.
20 You know, it is fascinating, and I wish we had time to go into
21 some of our other results because it appears that that is
22 exactly what is happening to us, and we thought that an
23 average system, if you want to look at the endocrine system,
24 if you want to look at the cardiovascular system, look at the
25 renal function or whatever you want, every single organ seems

6 1 to be getting a new reset of some sort, and there are ^{VARIOUS} ious
2 changes that are occurring, and of course, a lot of these
3 interrelate. As a matter of fact, the vestibular thing may
4 even relate to some of our cardiovascular things, too. There
5 have been some theories about some interrelations back and
6 forth, and we might get into that before the day is over, but
7 I wondered, do you have any feeling about the proprioceptive
8 role here? Do you have any ideas about whether that might
9 be playing a role?

10 DR. BRACKMANN: Oh, I am sure it must, although to
11 quantitate the percentage and so on, I would have no idea of
12 how to do that. I suspect a way to do it would be to compare
13 people who do have labyrinthine problems without zero gravity
14 in a clinical setting versus the people that do and compare
15 them on the rails and so on, but that would be very difficult.
16 I am sure that both -- if you take the balanced system in a
17 very simple way, the way that I could think of it and explain
18 it to patients, you know, it is not only ears. It is eyes,
19 proprioceptive and everything else fitting in, and to say what
20 percentage of what is impossible. It is just impossible to do,
21 but I think that certainly that has to be a role in both, but
22 how much I have no idea. I think that if you accept the
23 principle of the vestibular system working, you know, by
24 putting in a tonic impulse, and suddenly the tonic tonicity from
25 the otolith is gone, you would have to think then that

7 1 probably there is a lack of inhibition coming centrally,
2 and I was unaware of the lack of inhibition of the deep
3 tendon reflexes, but I think the probably the same thing
4 happens there, that the normal proprioceptive input is absent
5 for this period of time. So immediately postflight when you
6 test these people there is no inhibition, and they have
7 increased deep tendon reflexes. I think that probably the
8 same thing happens in the vestibular system, that you are
9 losing the normal impulses coming back. They are lost during
10 the period when there is no tonicity going in and perhaps
11 when you come out of that environment you have a hypertonicity
12 again, you know, coming out which upsets the balance, and
13 then there is another period of compensation.

14 DR. BERRY: Okay, Wally?

15 DR. JOHNSON: There are a number of things here
16 that I would like to bring forward. One of them is that I
17 noticed in reading ~~in reading~~ your booklet, Dr. Berry, you
18 mentioned that there is a potassium loss with tissue
19 breakdown. I cannot help but wonder whether this is not
20 actually contributing to this motion sickness sensitivity
21 because Dr. Doloman and I did some research recently with
22 squirrel monkeys in which we transferred the endolymph into
23 the perilymphatic space where the nerves come out on the
24 utricle or saccule of the semicircular canals. The endolymph
25 is high in potassium with respect to the perilymph, and we

8 1 were able just by taking some endolymph and applying it to
2 the perilymphatic space around it where the nerves lead to
3 induce a spontaneous nystagmus. You could eliminate this
4 spontaneous nystagmus by flushing it away with perilymph
5 again.

6 Subsequent work we carried out indicates that what
7 probably happens is if you suddenly apply an increased
8 potassium concentration to the perilymphatic space you
9 depolarize the nerves, and this causes an irritation, and if
10 it is continued long enough the effects are these. First of
11 all, you get an increased sensitivity to motion, and then this
12 is followed by a decreased sensitivity to motion, and I have
13 not any definite evidence that this is directly applicable
14 to motion sickness changes in sensitivity, but I cannot help
15 but wonder, do you think that this might be applicable here,
16 because you have found in your astronauts that there is an
17 increased potassium due to tissue breakdown? Whether this
18 -- I mean this might be applicable to changes in basic
19 sensitivity.

20 DR. BERRY: You said increased, do you mean --

21 DR. JOHNSON: Increase in potassium.

22 If you had a withdrawal from the body it has got
23 to go somewhere. So, it is going to get into the circulation,
24 I guess.

25 DR. BERRY: Okay. I see what you mean now. I

9 1 was not sure what you were saying.

2 DR. WHITE: That is a relative increase in the
3 plasma, in blood?

4 DR. BERRY: Exactly. You are saying that you
5 pull some initially into the bloodstream as you pull it out.
6 That does appear to happen. I guess one of the most marked
7 times that we had that occur, of course, was on Apollo 15,
8 where we had that first episode, and we wondered at that time
9 because one of those individuals we talked about this morning
10 on that flight, Irwin, that was the first time we ever had
11 postflight effects, too, and he had these effects which lasted
12 for some five days postflight. He had this feeling that he
13 was dizzy. He had vertigo, dizziness. This is the astronaut's
14 word, but he had vertigo if he moved his head, just sitting
15 at a table like this. He also had this feeling of being
16 tilted head down 30 degrees if he were supine, and that lasted
17 for a good five days postflight, and he was down 15 percent
18 of his total exchangeable potassium postflight. We wondered
19 at that time, and I did not realize personally how high the
20 endolymph was with potassium, but we wondered about that. If we
21 were having this much trouble with fluid and electrolytes, and
22 there is a fluid and electrolyte balance going on with
23 endolymph, too, and maybe that is all tied up, but that is
24 about as far as we have gotten with it. So, I think that is
25 fascinating that you brought that up.

10 1 DR. JOHNSON: I think it is a subject for research,
2 but it also implies research into therapeutic procedures
3 because I am not sure just how it would be applied, but
4 certainly any method of offsetting this potassium imbalance
5 with electrolyte changes, I think it should be very carefully
6 administered. I mean we really have to look at this from a
7 long-term point of view as far as research is concerned, but
8 in the long term it might not only explain these changes
9 in vestibular sensitivity, but it might also lead towards
10 a therapeutic procedure.

11 DR. BERRY: It is interesting to just tell you for
12 a second that on this last crew it appears that as we got
13 out to the 60-day time period ⁽⁵²³⁾ this crew lost the least
14 potassium of any crew that we have had. They also had some
15 changes. We used to get extreme increases in aldosterone.
16 You know, that helps you to lose the potassium, too. We were
17 seeing up to 500 percent increases in aldosterone, and on
18 this flight we got some initial very high aldosterone levels,
19 and then it looks like we were coming way back down toward
20 the end of the flight, and we did not have increased
21 aldosterones postflight, and therefore in a postflight state
22 the potassium lost by K-42 was very minimal compared to the
23 other, and that has been an interesting thing to us that we
24 do not totally understand yet either, but it looks again like
25 maybe these oscillations are seeking the various systems to

11 1 get a balance, and if you go along enough in that environment
2 you are sort of damping out some of these oscillations and
3 getting more back towards some kind of a normal thing. Maybe
4 the body is taking care of that. That is the theory. I have
5 not got anything to back that except the kind of data we are
6 looking at at the moment.

7 DR. JOHNSON: I suggest it be considered. As far
8 as therapeutic drugs are concerned I cannot recommend anything
9 better than the Scop-Dex which we have already decided to use.
10 I know of some which are used clinically for spontaneous
11 nystagmus of various pathological conditions which are very
12 effective, but without bothering to name them they all do
13 have side effects which might preclude their use here. The
14 prominent one is sleepiness, and this you do not want.
15 However, I do like the approach that Ash Graybiel has brought
16 out just a little while ago and that is to see whether you
17 cannot build up a long-term immunity by establishing a
18 certain level in the bloodstream, but this, as you have said,
19 and I fully agree, should be earth tried on an individual
20 basis before you try this in actual flight.

21 Another factor which we do know affects motion
22 sickness onset is vision. If you put anybody in a
23 disturbing type of motion and give them things to read it
24 can hasten the onset of motion sickness. This is quite
25 distinct from visual fixation. This is actually reading.

121 I was wondering, do these astronauts have a great
2 deal of checklist reading to do when they go into the various
3 situations?

4 DR. BERRY: They sure do. Everything they do is
5 by a checklist, every single thing, whether it is an
6 experiment or what have you. They have checklists to go
7 through. The whole activation sequence is by a series of
8 checklists, and so they are constantly reading lists.

9 DR. JOHNSON: I was wondering if there were any way
10 that these checklists could be set up so that they would be
11 easier to read or in such a way that it would not involve a
12 lot of head movement occurring at the same time? I know they
13 have to do it, but there might be some improvement.

14 DR. BERRY: You are saying the same thing. You
15 are echoing what Dr. Brackmann said about head movements.
16 You are saying, "Do not do head movements." In light of
17 your previous research that should tie the --

18 DR. JOHNSON: That is right. I know you have to do
19 it, and you can carry head movements as if you had a sore
20 neck all the time and reduce the stimulus magnitude. This
21 leads to Dr. Graybiel's suggestion of having a therapeutic
22 orthopedic collar. I do not know whether that is practical
23 or not, but that of course is not vision per se, but I just
24 recommend that something might be done in this checklist
25 reading that they have to do or any other reading that they

13 1 have to do so that it might minimize the resulting head
2 movements.

3 DR. BERRY: Why don't we go around the table and
4 get some thoughts, and then we will come back and discuss
5 them, because I think one of the questions is, is this head
6 movement thing, and we want to discuss that, but I would
7 like to get everybody's views, and then we will know where
8 we all stand when we come back to it, okay? Fine, Dr. Wood?

9 DR. WOOD: I was thinking that you might give them
10 an auditory checklist, a tape.

11 DR. BERRY: I was thinking the same thing.

12 DR. WOOD: On this motion sickness the first question
13 anytime anyone is exposed to a new situation of motion,
14 whether it is a centrifuge or whether they go to sea or
15 something they are prone to get motion sick, and after about
16 two days you adapt to it, at least that is what the sailors
17 tell you, and on the centrifuge this has happened pretty
18 readily.

19 One thing that I was interested in was that
20 90-degree displacement where they go through this tunnel.
21 If he turns his head the same way each time he may have
22 displaced his vestibular apparatus just the same amount and
23 therefore reset himself when he comes out. So, maybe in
24 trying to come out of the tunnel he has set himself up in
25 his vestibular apparatus to see a 90-degree shift, and that

141 might be a very simple movement coming out.

2 Getting on into some of these other things, as far
3 as identifying individuals, do you want each of us to run
4 down the list?

5 DR. BERRY: Sure, if you would like to make some
6 comment as you are going down, I think that would be fine.

7 DR. WOOD: As far as identifying individuals, this
8 goes back to what we were saying with Dr. Graybiel that some
9 of these people who are well adapted to one type of motion,
10 such as our pilots who are flying these motion sickness
11 studies, if you put them in a different situation they are
12 not adapted to that, and they are going to be very sensitive
13 to it. When you have people who have been observers on the
14 centrifuge who are highly adapted to spinning in one
15 direction, if you spun them in the other direction it would
16 wipe them out as if they were brand new subjects. So, I
17 think the adaptation is very specific, and the zero G
18 parameter is probably the closest you could get to it, and we
19 tried this once with our drugs, and one of the people who
20 did not have drugs on the zero G flight became quite ill, and
21 the rest of us enjoyed it very much.

22 So, different people are susceptible in these
23 different environments, and you almost have to test them in
24 the environment to pick them out. So, their past history,
25 I think they are a \$2 bet. If they have a good past history,

15 1 I do not think it carries over quite well. In the therapeutic
2 procedures, of course, I am interested in the drugs. There
3 is one other drug combination I would like to suggest since
4 there is some trouble with the amphetamine. It would be the
5 Promethazine and the amphetamine, 25 milligrams Promethazine
6 and 5 milligrams amphetamine. You may have the best of the
7 two groups here because Promethazine, well, Scopolamine is
8 good for about four hours, and it wears out after that.
9 Then they are on the amphetamine, and amphetamine will run
10 you six to eight hours depending on the individual. It gives
11 me a good eight hours when I have to take it. I do not
12 particularly like the feeling, but Promethazine is a longer
13 term. It would be good for probably about eight hours.
14 So, amphetamine and Promethazine would be well matched as
15 far as duration. So you would give it about once every
16 eight hours.

17 DR. BERRY: Is that right? You could give a
18 25 Promethazine and a 5-milligram Dexedrine every eight hours?

19 DR. WOOD: Every eight hours, it should be. Of
20 course, this has not been tested out, but this should, from
21 the duration of the drug action, be a good mixture, and the
22 Ephedrine was bothering them on that other combination.

23 DR. GRAYBIEL: I think we have tried the drug for
24 its effectiveness.

25 DR. WOOD: We have tried the individual drugs.

16 1 DR. GRAYBIEL: Haven't we tried the Promethazine
2 and amphetamine?

3 DR. WOOD: I thought that was one that we wanted
4 to and did not quite get to.

5 DR. BERRY: Do you want to comment on Ash's
6 concern? I tell you what concerns me here in this drug
7 thing at the moment is your comment that you thing that the
8 Ephedrine dose of 50 milligrams is too large if you are going
9 to look at a repeated dose, because there are two of the
10 crewmen according to Jerry's work here with the crew that
11 tell us that they really want it. They are looking more at
12 the Promethazine-Ephedrine combination. If that is true,
13 we ought to sure hone in on what we have to do with that
14 because we are going to have some people going down the road
15 that maybe we cannot support if we are not careful.

16 DR. WOOD: I do not know. Of course, Dr. Graybiel
17 did the work on this. You know 25 milligrams of Promethazine
18 is your usual antihistamine dose when you take a dose of
19 antihistamine for your cold, but it is also an effective
20 hypnotic. So, the amphetamine offsets it. If you wanted
21 to give it for sleeping you could use it in place of the
22 Seconal, perhaps. So, it is a good drug in this particular
23 sense. The combination of the two would tend to offset this
24 somewhat. If the Ephedrine is causing problems over a period,
25 I would think the 5 milligrams of amphetamine would do all

17 1 right, and that small a dose of amphetamine should not
2 produce any withdrawal effects or cardiovascular effects
3 either unless you have someone who is a depressive type or
4 something, but even that, that small a dose over that period
5 of time should not do it because these people who abuse these
6 drugs, amphetamines take many, many times more of it or much,
7 much more before they get into these problems with withdrawal.

8 DR. GRAYBIEL: Excuse me, Charlie, what is the
9 time course of Ephedrine? How long would you say it would
10 be effective?

11 DR. WOOD: I would say that the Ephedrine in that
12 dose would probably run you six to eight hours, at least.

13 DR. GRAYBIEL: About as long as the --

14 DR. WOOD: About as long.

15 DR. BERRY: Have we got time dose curves on this
16 stuff somewhere, Charlie? Does somebody have them?

17 DR. WOOD: No, these are strangely hard to come
18 by. They are beginning to come out more in the literature
19 now.

20 DR. BERRY: That is what I keep finding. Every
21 time you try and pin down data on a drug you cannot even get
22 it from a drug manufacturer, let alone anybody else, and that
23 is pretty bad. That concerns me. If I were the FDA I would
24 be concerned, too.

25 DR. GRAYBIEL: These are beginning to show up more

18 1 now in the literature, but they just are not there. There is
2 a lot of variability, apparently from one person to another
3 person.

4 DR. BERRY: Of course, it may vary by individual,
5 too.

6 DR. GRAYBIEL: This was one of the reasons, but I
7 think this -- Let me see, what else do we have here before
8 I shut up? I would like to see some of these additional
9 combinations tested. This one we were going to test, but
10 we just have not been able to work it in because we are
11 limited in number. So, it is not on there, and that is one
12 that deserves a look.

13 I would love to see them test it aloft, but I know
14 the problems. Maybe when the shuttle is here we can work
15 something like this in.

16 DR. BERRY: Yes, I think you will certainly have
17 an opportunity in the shuttle to do that sort of thing. If
18 you have some ground-based data to put with it, I think it
19 will be very good. We ought to have a very interesting and
20 susceptible population I would suspect.

21 DR. VINOGRAD: Getting back to prevention, are you
22 recommending that we use drugs on flights routinely as a means
23 of prevention?

24 DR. WOOD: This would seem to me to be as close
25 to the situation as we can because our experience has been

19 1 that it is a fairly specific adaptation that you are running
2 into, so this activity in zero G, even if you would go in and
3 out would come closer to space I would think. Dr. Graybiel
4 has had a lot more experience with this than I have.

5 DR. GRAYBIEL: Yes, but I have already done a
6 lot of talking, and it is not my turn.

7 DR. WOOD: Your turn is coming.

8 DR. BERRY: We have talked about things being
9 specific here, and one of the things we have not talked about
10 here, or the two of you either, is all this discussion about
11 the aircraft flight and doing T-38 aerobatics and so forth.
12 My view of that from what you have all said and from what
13 Ash has taught me over the years says that it is a motion
14 specifically again, and you are not going to gain anything
15 by doing T-38 aerobatics beforehand. That does not guarantee
16 you that you are not going to have a motion sickness in flight
17 at zero G. Is that true? Is that a firm statement?

18 DR. WOOD: That has been our experience with some
19 of the subjects who were well adapted.

20 DR. BERRY: I do not have an argument that says
21 that that is bad to do. I do not think it makes you worse,
22 but I just do not think it makes you any better, and the
23 problem we have got is that we have got a bunch of astronauts
24 who are going to say, "We have flown," and we have got a guy
25 who is the head of the astronauts who is absolutely convinced

20 1 because of that that okay, that is the cure-all. I do not
2 believe that, but we will play hob ever getting rid of that
3 for the next 10 years for that very reason.

4 DR. BRACKMANN: I think, again, going back to a
5 couple of very recent experiences, an SR-71 pilot recently
6 I saw who lost all of his vestibular function on one ear
7 as well as his hearing, a sudden loss, sudden vascular or
8 whatever you want to call it, and whereas an average patient
9 coming in off of the street would have been incapacitated,
10 you know, four days in bed type of thing average and then
11 a variable period, you know, maybe a couple of months off
12 work, he was never incapacitated. In fact, he flew home.
13 Do you remember that fellow? Maybe you saw him, too. He
14 flew his aircraft home from Okinawa shortly after this
15 happened. He was a back-seat pilot for a while because he
16 lost his front seat privileges but was never incapacitated
17 nearly to the degree that an average person would have been
18 who was not attuned to suppressing vestibular function.
19 His ENG, with eyes open, he had no nystagmus. When he closed
20 his eyes he had 10 and 12 degrees of spontaneous nystagmus,
21 but yet he functioned. In fact, he said that he functioned
22 better in an aircraft than he did on the ground because he
23 was used to suppressing his vestibular function in that
24 environment.

25 So, I think that it is true that you can only

21 1 adapt to a degree. If I am given the choice of a person
2 who is used to flying and spinning and rolling and turning
3 and then is going to be subjected to abnormal stresses, I
4 will take him any day over someone who has no more stress
5 than going up in an elevator.

6 DR. BERRY: I think we would all agree with that.
7 It appears that pilots in general and test pilots in
8 particular appear to be more resistant now. The question that
9 has always been in my mind though is that because of what
10 they are doing or is that a selection process that has
11 happened, because with the natural selection that goes on
12 you wipe out everybody -- if a guy every time he gets into
13 the aircraft is going to barf, he pretty soon decides that that
14 is not his bag of tea, and he is not going to fly anymore,
15 and we have that happen in flight training all the time,
16 and we get rid of those guys, and so you had a natural
17 selection occur. I do not know. That has always worried
18 me a little bit in my own mind as to which is the chicken
19 and the egg there, and I do not know either, but I agree
20 with your statement.

21 DR. WHITE: I would seriously question his operation
22 of an SR-71, even though it is a pretty exotic airplane
23 would have any real tendency to do any acrobatics, and I
24 imagine his times and his letdowns are very, very mundane.

25 DR. BRACKMANN: No, but he flew T-38's and a lot

22 1 of other aircraft.

2 DR. WHITE: I am sure that he does not fly those
3 as a routine though. In other words, his SR-71 stuff is at
4 a different point in time, as T-38 and acrobatics and this
5 kind of stuff. It was Vietnam and maybe even before that.

6 DR. BRACKMANN: I was just basing on his vestibular
7 findings though that an average patient that you took and
8 closed his eyes, and he had 12 degrees of spontaneous
9 nystagmus would not be out playing golf, flying an airplane
10 and so on.

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DR. RUSSELL: I have one comment here. I think this is very consistent with many problems of man facing a different environment. I would like to take you into the ocean for a minute, and tell you that in the training of divers in the early days, we looked at the same things that you have, let us say dives in history, weight changes, heart changes, vascular dynamics, teleological findings, drugs, and so forth. Then we began to select, and actually I did this with the British Navy sitting in the same way, and listening to the same sorts of tests for divers that might give us some index as to which one we would have problems with and which we would not, which tests might give us direct information.

We came up with something like this. The best divers were those who had, one, high performance, which was interpreted in various ways, plenty of experience, and plenty of chancey experiences with vestibular stimulation. In other words, it did not matter what it was, under what conditions, whether it was a P-31 or whether it was ground or anything, but all types of stimulations, many of which were new. These were the people who did best.

So I sat down the evening that I received this call. I was playing poker on the commuter. I fed all of the information that I had on each of these people, and I came out with something that showed that all of the material which you have here is probably insignificant, as far as interpreting

1 which men are going to be the least likely to do it. In other
2 words, there was no relationship between weight changes,
3 heart changes, even electrolyte levels, vascular dynamics,
4 hematological, early in the course from which you could
5 predict these things. They were if you figured the number
6 of hours of chancey stimulations of something with some
7 relationships. That is why I asked about left and right
8 handedness, and many other oddball sorts of things that are
9 rather important sometimes. They are certainly important in
10 a marine environment, This was to see whether all of these
11 threw them into stimulation patterns in which they had to
12 have a chancey experience. The more I thought of this and
13 the more I listened to careful experiments that have been
14 done on this that probably chancey experiments with respect
15 to vestibular stimulation are probably the most valuable
16 experiences that the man can get before he goes up in there.

17 To design a chancey experiment is not an easy
18 thing to do. The British Navy lost a few people in trying
19 to do this, and we lost a few, too. So I don't know how to
20 practice crashing at 4 G or 2 G. It is not a very wise thing
21 to do.

22 I was also very much concerned.. I have always
23 been interested in why -- the physicians tell me this -- why
24 people with vestibular activity or vestibular dysfunction
25 are upset in the dark. Why do they get sick in the dark?

1 DR. TOROK: That is not an apposite function.

2 DR. RUSSELL: It is not a visual thing?

3 DR. TOROK: The visual is limiting to be in darkness
4 so that the basic fundamental control out of the three, two
5 are missing, and you can't function.

6 DR. JONES: It is not abnormal, the point being
7 that in normal circumstances, like in this, I have the
8 semicircular canal and otolith signals which when combined
9 into a pattern say that is what happened to my head. But if
10 I am in zero gravity, I am going to get a different pattern,
11 because there is no gravity vector moving. Consequently,
12 you have got to learn to reinterpret that pattern on the one
13 hand subjectively, but more importantly it has got to produce,
14 the new pattern has got to produce the old reflex, so you
15 have got to change the wiring diagram. If one, for example,
16 has some pathology in one part of the vestibular system
17 which is changing one element of it, then you are changing
18 the pattern of input given movement or inertial stimulus,
19 and you have got to reinterpret that again as a new function.
20 You can't say what the new signal is until you have had time
21 to relearn it.

22 So to me it is just as feasible for discrepancy
23 between different components of the vestibular system to give
24 rise to disorganization as between other sensory sources.
25 It happens in space.

1 DR. TOROK: The same would happen with a propriocep-
2 tic loss.

3 DR. RUSSELL: The last thing that concerned me was
4 the effect of drugs. I thought, too, this promethazine
5 aphenamine combination would be one worth trying, not at that
6 dose of aphenamine, but perhaps at a smaller dose, because
7 I am worried about the dexterity at these higher doses.
8 Again, in marine environments that sort of dose is not
9 conducive to getting all of the synapses to fire at one time,
10 sometimes, or at least fire in synchrony.

11 I would be for prophylactics, except that I remember
12 the famous statement of Fontana that the doctor who gives
13 his patients drugs to cure the disease does not necessarily
14 prove that he has cured the disease, but rather that the
15 drug has not killed his patient. I am not thoroughly
16 convinced from what I have seen here, unless there is an
17 interpretation I don't know, that they are that terribly
18 effective.

19 The last thing that I would like to comment is this
20 business of seconal. I dread seconal. I am in a drug abuse
21 program, the largest in the country, and this is one drug
22 I can't see in these men. If I took a seconal, I would be
23 out for two or three days. I would turn my name upside down
24 to see who I am. I don't know how they do so well on it.
25 I would be more in favor of something like vallium. Is this

1 the time to bring this up?

2 DR. BERRY: Yes. You can make any comment you want.
3 We havenot got any limit about that. There are a lot of
4 reasons why we have seconal. We are using some other drugs
5 which you saw. Chloralhydrate is being used, and we are
6 Dalmine. Dalmine has worked out very well for us. Thereare
7 arguments pro and con for all of these. They have been
8 utilized based upon preflight testing with the individual as
9 a choice, as to which one he responds to the best.

10 DR. RUSSELL: He is able to do his work load after
11 a seconal at a grain and a half?

12 DR. BERRY: Oh, yes. We wake them up an hour
13 after they have taken it. We have done it an hour after, two
14 hours after. That is why that drug was chosen, as a matter
15 of fact, because we had data on that and performance with
16 that in emergencies compared to not having the same kind of
17 data on other medications. That has been used in an aviation
18 environment. It is the one medication for sleep that has
19 really been tested well on an aviation and space flight kind
20 of environment.

21 We had a lot of fights and arguments about this,
22 but in high flights across the water here in aircraft we
23 used it. We put the people down with seconal and then jazz
24 them up with dexadrine, and then fly them across the water,
25 keep them going that way until theygot to the other side.

1 Then we put them down again with seconal, and then got them
2 up and put them on dexadrine, and fly them back. We used to
3 have some terrible fights about that kind of a program, but
4 it went on. We saw some people do that amazingly well.

5 There are people who do not do that. There is no
6 question about. You have to be very selective. I know people
7 who can't take a 5 milligram dexadrine. They are like they
8 want to bounce off the ceiling and walls. But if an individual
9 is that way, then obviously that drug is not for him.

10 I take 10 milligrams of dexadrine, and I feel like my heart
11 is going to pound out of my chest, as far as I am concerned.
12 That is just me. But 5 milligrams of dexadrine, and I don't
13 even know I took it.

14 I took a seconal about eight years ago, and I
15 think I am just wearing it off now. But I took a vallium
16 last night. I am very scared, but I have seen seconal
17 performance, a very definite fall in mental performance in
18 the people that I see. It may be that this is long time
19 abuse.

20 DR. BERRY: Oh, yes, I think that is right. These
21 guys don't take this when they are home normally, that is for
22 sure.

23 DR. TOROK: First what I perhaps have already tried
24 to mention early, with pathogenesis you have loss of
25 indication and experience, and you can never really blame

1 the vestibular sensitivity as the cause or for susceptibility
2 to motion sickness. It is something elicited by vestibular
3 stimulation where you might have susceptibility, and that
4 is automatic nervous innervation. It is rather a big unknown
5 area that I am referring to. We cannot pinpoint where this
6 is, but this is the experience.

7 That also maybe immediately answers how can you
8 select the best candidates. Let me tell you a very simple
9 experiment which we conducted not too long ago when we had
10 the so-called normal clinical test subjects. Those are
11 medical students and with your measures they have to be
12 declared as being healthy.

13 You do a very standardized vestibular stimulation
14 measuring all of the measurable data, for nystagmus
15 particularly, and then try to assess as much possible the
16 subjective reactions. This is one and the same magnitude of
17 stimulation in 100 people.

18 The monitoring was attempted in a very naive way,
19 by asking them if they felt a motion when they were turning,
20 because horizontal canal stimulation is involved, and this
21 causes a horizontal plane type of motion sensation. But if
22 they would imagine a very noticeable motion, we would term
23 that strength No. 1. The imaginable maximum type of
24 sensation, most unpleasant, which naturally is always
25 accompanied by nausea or maybe vomiting, would be numbered 10.

1 Now, the individuals are requested to answer the
2 question where would they put the sensation which they have
3 between 1 and 10. The answer, which was not surprising,
4 was 80 percent of these so-called normals had something
5 which was always between 3 and 5. Incidentally, nobody ever
6 said a single figure. Everybody would say 4 or 5, 3 or 4,
7 showing how difficult it is. But there it was, the 80 percent

8 There were exactly 10 people who had partly
9 vomited and answered it with 10, and there were 10 who had
10 no sensation whatsoever, zero.

11 The standard responses were naturally averaged and
12 worked from another angle, and there is where we conclude
13 they were really normal.

14 Therefore, I would say that this is maybe the area
15 where you can weed out the undesirables, the one who is not
16 normal, like saying the 3, 4 or 5 individual, who is not
17 normal in resistance, in autonomic resistance. This might be
18 the best candidate.

19 DR. BERRY: You said a standard vestibular
20 stimulation.

21 DR. TOROK: This was 100 cc's. You can take 20 cc's.
22 It does not really matter. It should be the same and
23 executed very accurately, taking tremendous care that you do
24 not do a little more or a little less. Then you control it
25 sufficiently. We use 100 cc's of 20 centigrade water applied

1 in the optimal head position, which means that the horizontal
2 canal is in the vertical plane, and the water is applied in
3 20 seconds. This is our time. It does not matter if you
4 change it.

5 DR. WHITE: Did you say all had nystagmus?

6 DR. TOROK: Sure, within normal limits, and
7 certainly symmetrical right and left.

8 Now, going back to prophylaxis, I have heard here
9 so many interesting things. I do feel that if we have a
10 traumatized system of vestibular end organs, habituation
11 may not be the right principle to be applied. It is eliminatio
12 of any added stimulus which under the circumstances would
13 look unphysiological, which is what it is. Therefore,
14 what Dr. Graybiel mentioned, let us immobilize the susceptible
15 person. Since it can be anticipated that recovery from
16 this traumatized end organ situation is only a factor dependent
17 upon time, three to six days, these people will recover just
18 as much as they would be exposed to motion or exercises for
19 which they have to pay a high price.

20 If I may just make one more comment, when
21 orientation is difficult or badly handicapped without visual
22 reference, why not increase the visual reference on a
23 constant basis in such an environment like a space lab.
24 Why not have green lights for the "up" for which the floor
25 is the reference point now, from the floor red, and toward

1 the floor green. This might be applicable for right and left.
2 Anybody who got up in the middle of the night would
3 immediately know where the switch is by feeling. I am sure
4 it would be easy adopt that method.

5 I don't know whether I should take more time.

6 DR. BERRY: All right, Dr. Ades.

7 DR. ADES: I am struck by the fact that everybody
8 has discussed all of these symptoms as though they are the
9 same thing and mean the same thing. I find a certain
10 difference between the symptoms on starting and the symptoms
11 on ending the flight. Motion sickness may occur at the end
12 of the flight, but it does not with as much regularity as
13 it appears at the first of the flight.

14 What does appear at the end of the flight is
15 suggestive of a deficit in the afferrant side of the
16 vestibula, that is, the odd gait and that sort of thing.

17 Now I am going to talk about something I am not
18 at all ready to talk about. I think something that has to
19 be recognized is the rather great lability of synaptic
20 termini in the hair cells of the vestibular system on the
21 afferrant fibers. There is an increasing body of literature
22 that indicates that much of learning perhaps is the product
23 of luxuriant growth of axone endings, and that the reverse
24 of that is regress of these axones.

25 We do know that with the auditory and the vestibular

1 -- well, we know more about the auditory -- that the endings
2 on the afferent nerves are very labile. They go and come.
3 There is some evidence that in the auditory system at least
4 stimulation increases them up to a point, and then beyond
5 that point that high intensity sound diminishes them, which
6 kind of suggests that due to the similarity of these two
7 kinds of cells that maybe this works in the vestibular
8 system. Maybe the partial deafferentation of zero G
9 environment may diminish vestibular stimulation.

10 Maybe at the end of the flight, that has occurred
11 to a limited degree. Fortunately the situation so far is
12 such that we can go either way, and that might account for
13 the rather protracted number of days afterwards that the
14 symptoms were present.

15 DR. WHITE: Would the act of deafferentation on
16 the front end of this thing relate to the few days that
17 they had symptoms?

18 DR. ADES: Would they --

19 DR. WHITE: Would the process of deafferentation
20 going on relate to the few days that we have observed?

21 DR. ADES: I can't give you any particulars about
22 the time constants of this process, although I should think
23 so. I would guess that it might be.

24 That is what I have to say.

25 DR. GRAYBILL: What about the role of the rest of the

1 discharge? Doesn't that do something for the system?
2 You close your eyes at night. After a kitten is three weeks
3 old, you can sew its eyes shut and it will do very well. In
4 the first three weeks, out.

5 DR. ADES: I can't tell you.

6 DR. TOROK: It is very, very likely that the
7 vestibular discharge is diminished in zero gravity. It is
8 there.

9 DR. GRAYBIEL: There is no question from the stimulus
10 due to gravity, but it has a residual resting discharge.

11 DR. TOROK: Definitely.

12 DR. ADES: It has had movement in flight. The
13 question is, is that sufficient to keep the synapses all
14 working and firing in order.

15 DR. GRAYBIEL: Let us say the head should be fixed
16 relative to the stars. There still would be a chemical
17 discharge, a spike discharge.

18 DR. JONES: I would go along with you, yes, that in
19 fact the afferent input in the unstimulated state will stay
20 the same, and I base this on experiments which we have
21 recently done partly at Ames and partly at our own laboratory,
22 in which recording nerve cells in the vestibular receiving
23 area of the brain stem of a cat, which is placed in a steady
24 horizontal attitude, and separating out those cells which
25 respond by excitation with upward acceleration and excitation

1 with downward acceleration, and examining their spontaneous
2 levels of activity, one might have expected that those
3 associated with an upward acceleration, that is to say, the
4 effect of gravity, would in fact have a higher spontaneous
5 activity at rest than the ones normally accelerated by
6 downward going, but in fact, they are statistically identical,
7 which means they are not merely indistinguishable statistic-
8 ally, but they come out to the same actual number of 15
9 action potentials per second to the nearest whole number.

10 So I can't see any difference or any extra input
11 in the steady state due to the presence of the unmoving head
12 in the gravitational field.

13 DR. GRAYBIEL: Do you believe there is a constant tonic
14 stimulus due to gravity?

15 DR. JONES: I would say that the system in the
16 brain learns that whatever is coming in under the steady
17 state condition means I am under one G. When I change from
18 that, then I have changed that one G situation. So the brain
19 interprets what it gets under the one G situation as one G.
20 If you alter the Z up and the Z down --

21 DR. GRAYBIEL: What you are saying is that the spike
22 input may be the same; the interpretation is central.

23 DR. RUSSELL: Where do you get your input,
24 from proprioception? The brain has an input. The brain
25 does not create this itself.

1 DR. JONES: I am sorry, I am not quite with you.

2 DR. BERRY: What he is saying is that in the zero
3 G state, where do you get it?

4 DR. RUSSELL: Yes, where do you get your input?

5 DR. JONES: The fact is, you see, just as you and
6 I are sitting here today, you and I have about one million
7 action potentials per second going in from both sides, from
8 the canals only, let us say. That is a numerical figure
9 which is about right. That is with the cupula in the
10 central position. So it in the unstimulated state, they are
11 actively feeding information to the brain which says zero
12 angular velocity of the head, which is as positive as 20
13 degrees per second when they are slightly different. So the
14 fact that there is no difference between the two sides does
15 not mean there is no input. The input is there. It is
16 positively saying something. What I am saying now is in the
17 gravity situation, our results currently suggest very strongly
18 that the steady state situation with the head oriented
19 relative to one G is in fact a balance Z plus-Z minus input.
20 What you then register are changes from that.

21 DR. RUSSELL: Don't you register changes when you
22 take the vestibular apparatus out?

23 DR. JONES: Of a different kind. You won't get
24 that input, however.

25 DR. RUSSELL: Of a different kind?

1 DR. JONES: It may be coming from joint afferrants
2 or stable receptors.

3 DR. RUSSELL: Don't they have proprioception?
4 I know in snakes they do.

5 DR. JONES: I don't quite see what you are aiming
6 at. If you take the eyes out, you lose vision.

7 DR. WHITE: Don't some of the comments that were
8 made here verify that, that the men in the act of stimulation
9 had nystagmus, had the feeling then as long as they continued
10 the activity, and as soon as they quit, whatever was
11 interpreting that shut down or suppressed the event, which
12 was described I think by all of the astronauts.

13 DR. JOHNSON: It has a metabolic origin really.
14 This tonic discharge is a metabolic rather than a gravity
15 function, and when gravity affects it, sure, there is a change.
16 It is the change that counts.

17 DR. JONES: That is nice. The astronaut has to
18 arrive at a new steady state, and that is what he is adapting
19 to. That is what all the problems are about that we have
20 been hearing today.

21 DR. GRAYBIEL: But behaviorally, and I think eventually
22 this is a good test, you have to go back to behavior -- the
23 fact, let us say, that a person in the counter roll position
24 maintains his counter-rolling, let us say, for seven or eight
25 hours, when you release the stimulus due to gravity, he does

1 not roll. So I don't know how much it has to do with a
2 particular pattern of input, but I would think that the pattern
3 of input would be important in determining the counter roll.

4 DR. JONES: In other words, you are suggesting
5 that the system is not adapted out of the steady state
6 condition. I think an alternative explanation which supports
7 that view from our experiments is that the equal spontaneous
8 activity of the Z plus and the Z minus cells would not be
9 due necessarily to adaptation, although I think a large
10 proportion of it is, but also to systematic biasing of those
11 cells' excitability characteristics in the resting state.

12 DR. GRAYBIEL: In the case, you move your head. You
13 can't avoid a little.

14 DR. RUSSELL: You cannot even in the absence of the
15 eyes -- I am talking about in insects -- in the absence of
16 eyes or vestibular apparatus, the animal knows where it is
17 in gravity, because of the proprioception of its muscles.

18 DR. JONES: To an extent, but not as well as he did
19 with his --

20 DR. RUSSELL: No, any more than thermal receptors.

21 DR. JONES: The balancing organ, as I see it.
22 would not have been evolved unless it had been useful. For
23 example, a very good numerical example of what you are saying
24 I think is indicated by Nashiner's experiments, who takes
25 an individual standing on his ankle joint, and measures by

1 systems analysis the extent to which feedback from the
2 periphery is operating to maintain his posture when compared
3 with the input from the vestibular balancing organ. He finds
4 in his labyrinthectomized subjects that he has six times
5 increase of gain in the feedback from the peripheral limb
6 in those subjects, because they have lost their vestibular
7 system, but their end point is met when they are disturbed
8 at an earlier point when they have their vestibular system.

9 DR. WOOD: But they still fall as soon as they
10 close their eyes, so the other added input is not sufficient
11 to maintain them. All of our deaf subjects, after they close
12 their eyes, you --

13 DR. JONES: But despite the presence of the vision,
14 Nashiner has shown quite clearly that you up the gain of the
15 afferent information from the periphery by a factor of six,
16 which is huge. So the implication is you are better off with
17 it.

18 DR. RUSSELL: I don't doubt this, because I see the
19 evolution of this. I am trying to think of coming to the
20 next part of the experiments in lower animals. The one that
21 excited me was the spider thing. Everybody said this was
22 a high school kit. I remember publishing on this in 1953
23 rather extensively, centrifuging spiders and watching how
24 they build their webs, and things like this. And of course
25 Witt has done fantastic work in this. We have done a lot

1 with insects and so forth, and find that there are many things
2 that they can do without, and still with their proprioception
3 about the second time around they can spin a pretty good web
4 to catch an insect that does not even exist.

5 DR. JONES: I will give you another example. If
6 you drop a cat, it lands very comfortably. If you take its
7 semicircular canals out, it does the same. If you take its
8 otolith system out, it collapses. Two years later it still
9 collapses.

10 DR. ADES: Vision has something to do with that, too.

11 DR. JONES: He can't overcome that with vision, not
12 from a short fall.

13 DR. ADES: Barr did that experiment in about 1932,
14 and the cats were not as good, they did not fall as well,
15 and they had to fall a longer distance to make the turn, but
16 they made it, with either their vestibular system or with
17 their eyes.

18 DR. JONES: I am talking about a different thing
19 altogether.

20 DR. RUSSELL: We do it every day in the lab with
21 mice. That is one of our tests.

22 DR. BORISON: A cat will fall on its feet even if
23 it is labyrinthectomized if its eyes are uncovered. There
24 is no problem. It does it all the time.

25 DR. JONES: It depends on the height from which you

1 drop it.

2 DR. ADES: Well, yes, but you can do it.

3 DR. RUSSELL: It won't do it in the dark.

4 DR. BORISON: It depends on whether it has its eyes
5 covered. You know, one of the things that I find problematic
6 are the relative time constants of the semicircular canal
7 fluid movement and the otolith movement. The difference is
8 a fraction of a second in the case of the otolith as compared
9 with some seconds for the semicircular canal. I was impressed
10 by the need for so-called loading of the otolith. It seems
11 to me there should be a simple mechanical way because of the
12 short time span of loading, even in space. That is to say,
13 making use of a sawtooth movement. If you use an oscillating
14 movement that is fast in one direction and slow in the other,
15 say at the rate of 30 per minute, it does not seem to me that
16 it needs to be done to a very large amplitude. After all,
17 you are only trying to get those otoliths to stay in a
18 position in relation to the hair cells.

19 Of course, you can also try unloading at one G
20 by simply reversing the sawtooth, so that you could use
21 this in a way. You could use this for habituation on earth
22 or on land for loading in space.

23 DR. BERRY: I am not sure how you would offload it
24 on the ground.

25 DR. BORISON: What we would do, you see, is by

1 providing the inverse stimulus, namely, a fast movement up
2 and a slow movement down -- I am sorry, it would be the other
3 way around. It would be a fast movement down and a slow
4 movement up, so in effect what we would be doing is lifting
5 the otolithic membrane off the hair cells by the difference
6 in density to the endolymph. I understand the endolymph
7 is relatively viscous, is that right, in the otolith.

8 DR. GRAYBIEL: Well, it is in the membrane.

9 DR. BORISON: I know that, but I don't know what
10 the density of the endolymph is. Is it the same? I had the
11 impression that it was a little more vitreous humor. That
12 is not true?

13 DR. JONES: No, it is merely that it behaves like
14 viscous fluid in the very tubes of the canal because of the
15 dimension characteristics.

16 DR. BORISON: Of course, it is the same in the
17 canals as in the otolith organs.

18 DR. BRACKMANN: No, the otoconia are suspended in
19 a more viscous fluid. Isn't that true? The endolymph itself
20 is a specific gravity one, but the otoconia are suspended
21 in a gel.

22 DR. BERRY: Isn't it a gel like fluid? I thought
23 it was a gel like fluid. Is that right?

24 DR. JONES: It is held in a kind of sponge like
25 structure in which the gel sits.

1 DR. GRAYBELL: That is part of the membrane, and there
2 are shearing forces and shearing movements.

3 DR. BERRY: Melvill, do you want to hold forth on
4 some of these things. We will go right around the table here.

5 DR. JONES: What would you like?

6 DR. BERRY: Why don't you start at the beginning
7 and just run down the way you feel on the questions.

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1 DR. JONES: The main thing that I see coming out
2 of today is, for me, that whereas in the past in vestibular
3 problems associated with flying, our problem was mainly the
4 discovery of causes and the acute disorientation of flying,
5 while the problem today in the space flight environment is
6 one of chronic adaptation, which amounts to what we normally
7 call habituation in this sphere. So it seems to me that as
8 so far as the more basic kind of investigational approach
9 having a part to play in this real life situation, the study
10 of habitutive characteristics is going to be most helpful.

11 It seemed to me that one of the first things
12 though in habituation is to understand what habituation is
13 all about, to formulate the physiological goals toward which
14 the habituation is trying to move the central nervous system.
15 So perhaps stage one might be one in which useful dividends
16 are to be had from commissioning someone like Larry Young and
17 his group at MIT to make a systematic study, assuming a
18 model such as they have evolved, and never mind if it is right
19 or wrong, but assuming a particular starting model, making a
20 systematic analysis of the ways in which the patterns of
21 sensory input or output from that model will change for a given
22 pattern of head movement in the zero gravity as compared to
23 the one G field. There is an enormous variety of different
24 combinations of pattern change, such as the ones we are talking
25 about now, where you merely rotate your head from side to side.

2

1 An alternative one is rotating your head from left to right or
2 forward to aft. Another is lateral movements of the head such
3 as this, where I am bound with changing direction of the
4 gravitational vector, of the apparent gravitational vector,
5 because of the summation of real accelerations in gravity to
6 be absent although the same head movement is induced in the
7 zero gravity environment. So there is a whole range of
8 combinations of sensory input which are going to be different,
9 because you are in a zero gravity field.

10 This could, it seems to me, provide insight into
11 searching rationally for the goals to which the habituating
12 process is working. If one were to know what the goals were,
13 then one could perhaps search sensibly for prehabitation
14 technology on the ground. So that would be my first general
15 approach.

16 The next thing that comes to mind is that one is
17 asking the question of "What kind of processes are involved
18 in the habituating process." One has thought perhaps in the
19 past that when discrepant sensory inputs are matched in the
20 central nervous system, habituation occurs. That is not
21 good enough today, when we know from not only reasonably
22 remote past but especially from the current world of physio-
23 logic of motor control, that in fact the sensory signal that
24 comes in from a real given outside stimulus such as a head
25 movement is very much dependent on the motor signal that has

3

1 gone out to the muscles to produce that movement. For example,
2 one that we know about is that we can modulate the sensitivity
3 of stretch receptors by gamma afferent information.

4 One of the current new looks is that rather than
5 have afferent information coming from the muscles back
6 through the spinal cord in this fashion, to update in an
7 ongoing way a continuous controlled process. One of the new
8 looks is that in fact we establish motor control by generating
9 patterns, preprogrammed patterns of exiting information
10 from the cortex, which then operates simultaneously on the
11 alpha motor neurons and the gamma motor neurons. So if you
12 produce the movement that you intended with that pattern,
13 you get no change in afferent information. It is only when
14 an unexpected phenomenon occurs, and it is commonly called
15 loading, that when unexpected loading occurs, a change in
16 afferent information occurs. This then would go all the way
17 up to the cortex, not stopping at the brain stem level. It
18 goes, we know now from good neurophysiological work, that
19 goes with very short latency up to the cortex bypassing even
20 the sensory cortex, going straight to the motor cortex.

21 What looks to be a new idea, is in fact the central
22 nervous cortex is acting as what is described as a servo
23 assistance to the pattern outflow that comes from that cortex.
24 So changed afferent information as a result of the motor
25 signal comes back and tells you how to change the pattern.

4 1 Another commonly known example is of course the
2 2 afferent supply to the stimulus system. There have been
3 3 indications from particularly the work of Klinkert in Berlin
4 4 which has shown with gold fish, for example, which is
5 5 instructed to turn by an optokinetic stimulus, that when it
6 6 has turned passably, there will be an afferent inflow from the
7 7 vestibular canal system. If it is now paralyzed with a muscle
8 8 paralysis agent, the optokinetic stimulus is established,
9 9 then there are changes, although the animal has not actually
10 10 rotated, changes in the primary afferent input, which are of
11 11 the right direction to have nulled that afferent input if the
12 12 movement had been actually intended.

13 There are other situations, and perhaps one cannot
14 14 go too far, but I think it is very important, the age old
15 15 motor pyramidal motor control system, which we used to think
16 16 comes from the pyramidal cells in the motor cortex, and we
17 17 now know comes from a much much wider source. This not only
18 18 goes down the cord to generate motor responses, but sends
19 19 collateral enervation to enervate quite intensively the
20 20 dorsal column, the big dorsal column sensory ganglia in the
21 21 nucleus gracilis and cuneatus. So the motor signal that is
22 22 going out is modifying the sensory signal coming in at
23 23 essential level.

24 Finally, we have recently just shown that even in
25 25 visual pathway, that the retinal information going back

5 1 through the neural afferent projections is substantially
2 2 modified by coincident ocular motor outgoing signals. So I
3 3 see the habituation process as one in which it is the whole
4 4 sensory motor integration which is being modified in the
5 5 central nervous system but always toward some objective
6 6 criterion, what you might call optimization criterion, which
7 7 I would call a physiological goal.

8 We have recently hardened this idea by generating an
9 9 experiment in humans, in which instead of wearing a pair of
10 10 spectacles, one wears a pair of reversing prisms, which reverse
11 11 the visual field outside. Then when I turn my head to the
12 12 left I have a vestibular ocular stimulus turning the eyes to
13 13 the right. If I look through these prisms, the optokinetic
14 14 visual tracking stimulus requires the eyes to go to the left.
15 15 These two drives, motor drives, are now at the exact opposite
16 16 poles, diametrically opposite to one another. In order to
17 17 see, one would have to follow the optokinetic stimulus to
18 18 stabilize the visual image.

19 Under these conditions, where we have one degree
20 20 of freedom, just rotation in this plane, one degree of freedom
21 21 in the change of the stimulus, in ten days the human vestibular
22 22 ocular reflex arc is reversed, in humans, adult humans, not
23 23 babies. So that is a habituating process in which the visual
24 24 information, image slip on the retina, has gone into the
25 25 central nervous system, and modified a remote vestibular ocular

6 1 response, not just slightly, but diametrically changed it
2 2 from one condition to another. That to me is what habituation
3 3 is all about.

4 Here we know what the goal is. That is why it is
5 5 chosen. We know that image stabilization is the goal.
6 6 We can therefore say how close to the goal the habituation
7 7 process has actually brought us. We know it brings us in
8 8 about 12 to 15 or 18 days very close to the almost perfect
9 9 optimal goal of actual reversal of a disynaptic reflex arc.
10 10 There are other pathways of course than the disynaptic ones,
11 11 but this is essentially the disynaptic reflex path. So where
12 12 does this bring us? It brings me to the point where it seems
13 13 that a great deal more needs to be known what goes on when
14 14 habituation takes place in the central nervous system. I am
15 15 sure that is what is going on in these astronaut experiences,
16 16 both when they go into orbit, and when they come back onto
17 17 the ground.

18 We cannot tell what the reorganization is aiming
19 19 at until we know what the goals of the physiological changes
20 20 are. So this is why first I suggest that one searches through
21 21 people like Larry Young and his capability for some kind of
22 22 organized statement of what one would expect the new goals to
23 23 be, on the one hand, and on the other hand, using other methods
24 24 such as the ones that we are currently using to work out the
25 25 rules of the habituation process. Having been one of these

7 1 long-term subjects myself with the reversing prisms, where
2 you wear them day after day after day, everything that the
3 astronauts said about discomfort, nausea, recovery of the
4 situation by resting the head and so forth, spelled out
5 exactly one's own experience. One puts on these prisms, but
6 within the first ten minutes one is practically vomiting if
7 one is really walking about. If you lie down, before you
8 start to actually vomit or be nauseous, one can overcome that
9 just as the astronauts were describing.

10 Gradually by using self-controlled adaptation, one
11 can in the course of time produce adaptation which leads to
12 discomfort rather than nausea. Lack of proper feeding lasted
13 three days regularly in all our subjects. By six to seven
14 days one was starting proper meals, just as these astronaut
15 subjects were describing, with the added feature that the
16 reverse sequence was almost identical after taking the prisms
17 off. It allowed us to see that even after 28 days we were
18 still improving our habituation, because we knew what the
19 goal of the habituation process was. So with 28 days on the
20 prisms, one was still habituating at the end of this. Taking
21 the prisms off at 28 days after they were off, one was still
22 rehabilitating back to normal.

23 DR. GRAYBIEL: How long did it take you to get back
24 to normal?

25 DR. JONES: The same 28 days that it took to

8 1 establish it in the astronauts.

2 DR. RUSSELL: Would you think that this experience
3 with reverse prisms, just doing them periodically, might be
4 of value to them?

5 DR. JONES: Here comes the question of specificity
6 that we were discussing before. You see, in these experiments
7 our prisms were not reversing in the vertical plane.

8 DR. RUSSELL: After the experience itself --

9 DR. JONES: Let me just take this point then, that
10 whereas we were habituating in this plane, we systematically
11 as a control compared the responses in the vertical plane to
12 the horizontal. There was no change from beginning to end.
13 Consequently, one is left with the conclusion that here is
14 high geometric specificity, just as we have seen specificity
15 for right and left handed persons in rotational experiments.
16 One would very much doubt that there would be transfer from
17 this kind of habituation to the other, which is associated
18 with the zero gravity field.

19 DR. RUSSELL: Wouldn't that depend on where the
20 decision was made? Supposing that it was an experience that
21 was made in the cortex.

22 DR. JONES: I don't know. What do you think?

23 DR. RUSSELL: I don't know.

24 DR. JONES: Of course you have to be rather careful.
25 One is a dangerous individual when you take these prisms off

9 1 for quite a long time.

2 DR. RUSSELL: I was not suggesting doing it up there.

3 DR. JONES: Coming down more to specifics, this
4 takes one right into the realm where I personally could see
5 where one could make useful experiments which would have an
6 input. I am afraid that they tend to be rather more basic
7 when directly applied. For example, one of the most interesting
8 things today that I think I have seen, from my personal
9 viewpoint, is the failure of the rotating turntable while
10 head movements are being made, after the return to the ground,
11 to produce the usual nauseating effects in subjects who have
12 been in space. Is this because their system is without the
13 capability of establishing a gravity, knowledge of the gravity
14 vector, because it has forgotten how to. In other words,
15 it seems to me that it suggests very strongly that in fact
16 the Coriolis so-called stimuli which are so perturbing are
17 most likely to be in normal people due to the discrepancy
18 between the canals and the otolith system under those condi-
19 tions.

20 That is to say, if I turn my head this way, I
21 normally associate it with canal stimulus here, and G vector
22 here. If I am rotating, I get a canal stimulus here and
23 a G vector here, and that is a discrepant input. If in fact
24 the central nervous system of the astronauts has forgotten
25 to make use of the G vector, then that discrepancy will not

10

1 be there, and that is my interpretation of how this happened.
2 Could one possibly imagine using the prism experiment after
3 return on an individual, to examine the nauseating effect
4 of a strong habituating stimulus itself, on the grounds that
5 if that in fact also failed to produce a nauseating effect,
6 then the phenomenon that you have already shown would be
7 more likely due to having adapted to a nauseating stimulus
8 per se, than due to failure to establish discrepancy in the
9 vestibular system. So that could be one possible experimental
10 use of that system.

11 It seemed to me, getting more practical now, that
12 there may be a case for attempting prehabitation on the
13 ground to adopt not prism reversal, not rotational stimuli,
14 for after all the vestibular system responds to rotation
15 as well in zero gravity as on the ground presumably, but to
16 provocative linear accelerative stimuli.

17 The early experiments of Went, I think pre-last
18 World War, which showed a quarter of a cycle per second,
19 the most provocative linear acceleration, was reproduced in
20 my sabbatical year of study that I did at Ames Research Center,
21 when we established alternating linear gravitational fields
22 without sensation of rotation by moving very fast in forward
23 flight using angular changes in pitch, which at that fast
24 forward speed, would produce large changes in vertical
25 acceleration with subthreshold angular movements in pitch,

11 1 because of the high speeds and associated large gravitational
2 vectirs for small angular velocities.

3 Under those conditions, we found that at the low
4 frequency stimulus, the experiment had to be abandoned. Not
5 only the experimenters became nauseated very quickly to the
6 point of vomiting, but also the test pilots themselves, which
7 merely replicated earlier experiments that I had personally
8 conducted at Farmborough, where we were examining tolerance
9 to oscillatory conditions in roll and pitch in real flight.
10 We had to abandon the quarter cycle a second pitching os-
11 cillations, because hardened test pilots were vomiting in
12 the cockpit very shortly after stimulation.

13 The added feature was that as you went to lower
14 frequencies of stimulus in flight, still the subthreshold
15 angular, but generating very sizable, .3 to .5 G linear
16 acceleration changes, the subject with his head strapped in
17 place was not affected. Under those conditions, the experi-
18 menter, who was moving about and changing his head altitude,
19 very quickly became ill even at one-twentieth of a cycle a
20 second, very low frequencies. There is no physiological
21 sensible angular stimulus, except for the head movements, which
22 are fast enough to be okay. So that discrepancy leading to
23 that nausea must surely have been due to the head movements
24 in the changing linear acceleration field.

25 My only suggestion is could one perhaps achieve

12 1 useful preflight habituation for the astronauts who are going
2 to be habituating to a change in the linear accelerated field,
3 by generating not so much angular head movements in a rotating
4 field, but changed attitudes of the head in a linear acceler-
5 ating changing field. The effect could be a possible source
6 of prehabitation stimulus, which might be more relevant nearer
7 to the specific problem of the real flight environment.

8 DR. BERRY: When you are talking about linear,
9 you are talking about oscillation in the vertical plane.

10 DR. JONES: Yes.

11 DR. BERRY: If you were to oscillate in the vertical
12 plane, your head movements are the same, is what you are saying
13 This would give you otoliths. That is sort of what Owen is
14 saying. You ought to pay more attention to what is happening
15 to an otolith versus what is happening to the semicircular
16 canal.

17 DR. JONES: We know from our recent Ames experim-
18 ents, that head movements in a strictly linear accelerative
19 field, a changing linear accelerative field, no angular
20 stimulus except for the actual head movement, generates nausea
21 as quickly as the rotating chair does. It might be that
22 would be nearer to the specific habituation that the astronauts
23 need.

24 DR. BORISON: Try a sawtooth rather than a sinu-
25 soidal one.

13

1 DR. JONES: It could be. I do not think it would
2 matter too much. I think the fact is that it is a changing
3 one.

4 DR. BORISON: At least you have introduced direction.

5 DR. GRAYBIEL: How fast were you changing head
6 movements?

7 DR. JONES: They would be normal head movements
8 with an experimenter moving about changing the --

9 DR. GRAYBIEL: You were stimulating the canals
10 very strongly.

11 DR. JONES: Yes, but within a frequency range which
12 is within their natural response characteristic, which is not
13 the case with moving one's head in a steady rotating field.
14 So my view is that the canal stimuli were all correct, would
15 not be misleading. The only source of misleading stimulus
16 must be linear acceleration. The frequency content of the
17 head movement is within its proper response characteristic.

18 DR. GRAYBIEL: Yes, I follow that. So that what
19 you are saying is that there was more chance really of fast
20 coupling.

21 DR. JONES: Between canals.

22 DR. GRAYBIEL: What sort of radius were you turning?

23 DR. JONES: I cannot give you the exact radius of
24 curvature, but the limits we set to the flight profile, which
25 was pitch like this, where one would never reach an angular

14

1 velocity higher than three degrees per second, and there would
2 never be more than a peak to peak angular change in attitude
3 of three degrees. These were at twenty seconds to a cycle,
4 too, you see, so it was way below the threshold for angular
5 stimulation.

6 DR. GRAYBIEL: Three degrees per second?

7 DR. JONES: At twenty seconds per cycle. The adaptiv
8 term has then reduced the gain in the frequency response curve,
9 way down by a factor of nearly five, six, or seven. Normally
10 that was our maximum angle of velocity. That was for the
11 sixty second periodic times. Normally it was much less than
12 that. When one looks at the frequency response of the canals,
13 you find that below frequencies, the gain is so attenuated
14 by one-twentieth cycle a second, that even three degrees per
15 second would be equivalent to something around .6 degrees
16 per second, nearly .3 degrees per second. It is very low
17 indeed. One has to take frequency into account as well.

18 Those are just two small points. There are various
19 other suggestions for experiments, but I think that I have
20 spoken too much.

21 DR. BERRY: We will come back. One thing that I
22 do want to say while we are at it here, and I know that we are
23 going late, but it is the only thing to do right now, is that
24 I do want you all to feel free. You have been stimulated by
25 a lot of material today. I would hope that certainly in the

15 1 experiment area in particular we have ample time for you to
2 do that. I would like for you to feel free when you go home
3 to think and put down in any terms that you so desire any
4 comments or second thoughts that come to you in any of this
5 material, and send it to me. I would be deeply grateful.
6 It would be very helpful to us. We certainly have a lot
7 of things here to look forward to, and the experiment area in
8 particular. So aside from what we have talked about here
9 on things that apply directly here within the next few weeks,
10 certainly there is going to be a great time to do the
11 experiments.

12 Let me get some votes from you. What you are saying
13 really is that you are agreeing with the statements that were
14 made over here about head movements, too. You say that you
15 do not make the head movements. That is what you are really
16 saying, in that environment, that is really not going to adapt
17 you. Is that what I am understanding you to say?

18 DR. JONES: No, I would not agree with that. My
19 view is fairly strongly, that if you lie on the bed without
20 moving in space, that there is going to be no adaptation at
21 all.

22 DR. BERRY: Okay, you are the reverse of what I
23 am hearing.

24 DR. JONES: That is right.

25 DR. BERRY: That is interesting.

16

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DR. JONES: For example, in our prism experiments
if our subjects lie on the bed --

2

3

DR. BERRY: Okay, your symptoms would become less
if you lie there, but you are saying that you will never adapt.

4

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DR. JONES: That is right.

6

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DR. BERRY: Dr. Torok says just exactly the opposite
of that, and I have heard three other people say the opposite
of that.

8

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DR. JONES: You take the example of the prism
experiment, the subject who lies on the bed gets no habituating
stimulus. The habituation process is not going to work towards
its new optimization goal if there is not a stimulus to make
it do so.

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DR. RUSSELL: I think this is an important experiment
as an experiment. I think that seeing where we do not know
where the interpretation is made in this, and I suspect that
it probably is made in the cortex, but this is another type
of chancey synaptic control that might be called upon under
unusual circumstances, and know how to respond.

DR. JONES: It takes time.

DR. WOOD: Add another vote to Dr. Jones.

DR. BERRY: You agree with that, too?

DR. WOOD: Yes, very much.

DR. JONES: I cannot see how without a stimulus,
as habituation results from a stimulus, and without the

17 1 habituating stimulus, it is not going to happen. You are not
2 going to change your wiring diagram in the CNS unless there
3 is a requirement to change it.

4 DR. RUSSELL: The experience, but not for the
5 habituation. The experience itself will be a new experience
6 the first time. The second time it will have gone through
7 it twice. I am not thinking about habituation, because I
8 do not know about how many times it has to go through it. You
9 say that it has to go through it for 28 days before it learns
10 a lesson.

11 DR. JONES: Let us say that it has a time, for
12 instance, of about five days.

13 DR. BERRY: It is obviously less than that in our
14 particular instance. It is happening in less time than that
15 in our particular one, compared to the prism work which is
16 28 days.

17 DR. JONES: No, that is very very similar, three
18 to four days. That is the time constant, just the same as
19 it is to yours.

20 DR. BORISON: What are you doing at zero gravity?
21 What difference does it make whether the person is lying
22 down or standing up? It does not make any difference.
23 Certainly if the person is lying down, the otoconia is still
24 going to be floating. I do not understand that.

25 DR. BERRY: I think that is what you are saying.

18

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DR. BRACKMANN: I am just saying that clinically
a large number of people either with labyrinthectomy, vestibula
nerve section, from whatever route, that they are very ill
and very dizzy on days one, two, and three. If you try to
move them to try to make them adapt, you will make them worse
and delay their recovery, whereas if you let them lie still
for three, four, or five days, and then ambulate them, then
they reach a certain period where certainly vestibular
exercises are helpful in helping them gain that last five
or ten percent. I think during the acute phase, that the
less they are disturbed, the better. Putting this into the
Skylab situation, I think that they are having a similar
vestibular storm, a readaptation to a different stimulus.

14

DR. JONES: I disagree with that.

15

DR. BERRY: You are implying pathology.

16

DR. BRACKMANN: Yes, I am.

17

DR. BERRY: What I thought would be an increase
in endolymph or whatever you want to say that has produced
that, for instance.

20

DR. BRACKMANN: I think that it is just a decrease
in the sensory input as a result of the zero gravity on the
otolithic structure.

23

DR. BERRY: Your pathology on the ground here and
your patients --

25

DR. BRACKMANN: Those patients have a vestibular

19 1 nerve section, and you are doing the same thing. You are
2 decreasing their sensory input in a very dramatic fashion from
3 the whole inner ear. This is happening on a limited basis
4 in the zero gravity situation from the otoconia only. This is
5 what I think.

6 DR. JONES: There is hardware that makes this a
7 different situation. In other words, the zero condition in
8 the central nervous system is one million action potentials
9 per second on both sides. You take one of those out, and you
10 have a difference of one million action potentials per second.
11 Habituation then sets in to bias off that difference. So you
12 have the habituated stimulus the moment that you have done
13 your pathology.

14 These guys upstairs have not got that habituated
15 stimulus at the lag stage.

16 DR. BORISON: Why not? It is asymmetrical. There
17 is no gravity influencing both sides simultaneously. Without
18 gravity up there, the otoconia on one side are moving one
19 way, and on the other side a different way. You have the
20 asymmetry as you would when you remove it.

21 DR. JONES: To my thinking similar habituation is
22 generating new patterns of muscular response associated with
23 the movement that you do in real life. So if I suddenly
24 drop from a platform here to the ground, I land as much as
25 anything because of the vestibular signals which are generated

20 1 with that pattern of accelerated change. I look at that
2 2 distance from the ground, and I guess very accurately what
3 3 the acceleration is going to be, and hence the time that I
4 4 am going to hit. We know that you can make that judgment of
5 5 when you are going to hit within about two milliseconds. It
6 6 is very accurate. The astronaut who is landing on the wall
7 7 from the push from the other side is not going to be exposed
8 8 to an acceleration. He is going to be at a constant velocity.
9 9 When he decelerates at the other end, he is going to have a
10 10 different vestibular stimulus to the one when he decelerated
11 11 on the ground. So he has to learn to make use of that
12 12 afferent information to generate a new pattern of muscular
13 13 response. That is what habituation is all about according
14 14 to me.

15 DR. BORISON: He has to come to learn to disregard
16 16 this abnormal activity.

17 DR. RUSSELL: I think your point about learning,
18 18 which you have not defined, is really the important thing.
19 19 That is why I say I do not think it is the experiment of
20 20 habituation that is really that important. The process of
21 21 whatever the nervous system does in learning this, which we
22 22 have not defined, might be the experience that might help
23 23 them along the way. I do not know. I would think that just
24 24 periodic exposures with reverse prisms, even to the place
25 25 upon earth that it made them sick, might put whatever this is

1 that you call learning to some advantage. I don't know. I
2 cannot do it rationally.

3 DR. BERRY: It depends. You cannot transfer it
4 from one environment to another. I think everybody is
5 agreed on that, so you have to learn this in that environment
6 some way. The key argument here is, is there a change in the
7 stimulus? I think we would all agree that there has to be
8 some change in the stimulus of a zero g environment. There
9 has to be or you would not have anything happen, all right?

10 If that is true, then do you have to add an additional
11 input to the central nervous system that says when I make a
12 movement something happens to me that is very bad -- do you
13 have to add that in order to adapt the individual to that
14 environment? Or should you have the individual hold his head
15 completely still in that environment and would he adapt in
16 the same period of time. That is the argument.

17 DR. WHITE: Or is the process one of the central
18 nervous system learning to suppress all these aberrant or new
19 stimulus?

20 DR. BERRY: But how do you learn?

21 DR. WHITE: I agree with that.

22 DR. JONES: My point is that we cannot hold that
23 view any longer because in our experiments you do not suppress
24 the vestibular or ocular -- you change the bloody thing. In
25 fact it never gets suppressed, it is changed with very clever

1 phase changes with time, so that it is an objective change,
2 a rewiring. That is why I feel that movement is necessary
3 to generate a systematic change in wiring of reflex response
4 mechanisms.

5 DR. BERRY: Yes, but you are not in zero g. In
6 your environment, you are not at zero g with your prisms.

7 DR. RUSSELL: I do not think that is an important
8 point. I think it is a learning that we are talking about
9 here, and it is the end point of learning that is important.

10 DR. BERRY: I do not think that anybody is arguing
11 about the learning. I think we are all saying that you have
12 to learn, and that the central nervous system has to repattern
13 itself and has to learn, but what is the necessary stimulus
14 for the learning? What they are saying, at least what I am
15 getting from three people at the end of the table is, and
16 I am not sure what Harlow says --

17 DR. ADES: I am waiting for a chance to vote.

18 DR. BERRY: What you are saying is that the oto-
19 conia are in such a state that you have, in effect, either
20 "de-afferented" -- and I don't know if that is a good word
21 to use in this instance -- but you are at least getting
22 spurious inputs from the otolith. Let's put it that way.
23 That input, you are saying, is enough to adapt it if you stay
24 perfectly still and create no symptoms for yourself, whereas
25 the other people are saying that is not so. You will adapt

1 only if you make large head movements in this environment in
2 addition to what you have initially. Is that clear?

3 DR. BRACKMANN: Might that have been answered in the
4 Gemini and the Apollo in which sort of by no choice on the
5 part of the astronauts they were maintained in a relatively
6 stationary position. On the way to the moon they got three or
7 four days of adaptation and when they were allowed the freedom
8 of lunar movement, they had already adapted to this, and there-
9 fore I would wonder if that might not support the position of
10 adaptation with non-stimulation.

11 DR. BERRY: It is true; The first time we really
12 faced this was in Apollo 8. Strangely enough, and I do not
13 understand it, but it's the odds again, as in the Apollo 7
14 experience, when we first had the capability to move about
15 freely inside a spacecraft inflight in our program, and they
16 had, at that time, no symptoms. They had other things. They
17 all ended up with upper respiratory infections and all sorts
18 of things that confused the issues, but they never had any
19 vestibular symptoms of any sort on that mission.

20 DR. WHITE: Maybe this is the SR-71 pilot experience.

21 DR. BERRY: That is very interesting, because then
22 when we flew to the moon, those guys in 7 did not get out of
23 their couches right away, within the first hour. They were
24 in no big hurry, but I am sure they were out in a matter of
25 hours. But in the case of going to the moon in Apollo 8,

1 we had one revolution around the earth, an hour and a half,
2 to get a lot of things done. So everybody was up and out of
3 the couch for the first time. The first time they did that
4 they said, whew, something has happened, and they got the
5 stomach warnings right away. When they got down into the lower
6 equipment bay and they had to do a number of navigational siting
7 and things, all three of them had stomach awareness immediately.
8 This odds thing is really terrible for us because we had the
9 same thing happen for us three and three on Skylab, each way.
10 The oddsmakers are not very good to us.

11 DR. JONES: Could I perhaps simplify the matter by
12 suggesting that the stationary position is a necessary one,
13 but not a sufficient one? That is to say, as soon as you
14 start to move, the fact that you have been stationary will not
15 tell you how to reuse your new messages when you do. The one
16 plus the other is the total picture.

17 DR. BERRY: Ash, do you have some other things you
18 want to add?

19 DR. GRAYBIEL: No, I don't think so.

20 DR. BERRY: We will come back and talk later. Dr.
21 Borison?

22 DR. BORISON: Maybe I am prejudiced, but I try to
23 minimize in my own mind the psychological aspects here, maybe
24 because I work with decerebrate cats so much. I think a
25 decerebrate cat vomits beautifully. I think it could adapt

1 in space without the cortex. I have a film which tells us
2 something about vomiting, and I think it may be of interest.

3 (Film.)

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JB1

1 DR. BERRY: Okay. That film does not leave me very
2 happy with what we have for agents.

3 DR. BORISON: That is the whole point. As a pharma-
4 cologist, I do not have much faith in drugs.

5 DR. BERRY: I got your message there. I think we
6 have one thing that I want to get a feel from all of you on
7 here, and then I think we can probably get to some of the
8 other areas. You realize that the key problem that I face,
9 if you were sitting in my shoes, is the launch scheduled now
10 for the 10th of November. We are going to go 85 days, and
11 that is not public knowledge yet, but if we do that, we have
12 three crewmen, and you have seen some data here about what
13 they have done and what we know about them so far on various
14 drugs, and what they have done so far as sensitivity is con-
15 cerned, and how good or bad that information might be in pre-
16 dicting, we have a problem of what can we do to assure their
17 capability to perform best in the first part of that mission,
18 knowing all of the things that we know right now.

19 I guess I would like to have sort of a vote around
20 the table to be sure, number one, what you each think. Do you
21 know anything new or different that we ought to do? It cannot
22 include much in the way of trying to habituate them, even if
23 we knew what that was here on the ground. I guess it comes
24 to that because of the timeframe in which we find ourselves.

25 I would like to run around again and make sure that

JB2

1 I do have a position on that, and then we will come back and
2 specifically ask about head movement things, as a second issue.

3 DR. WHITE: Also you want to note that complete
4 inactivity is not --

5 DR. BERRY: Well, complete inactivity is really
6 impossible. To really do that is almost impossible, to say
7 that you are going to do absolutely nothing. Now you can cer-
8 tainly limit activity. That is very plausible, or to modify
9 activity with or without medication. Both of those are options
10 certainly, but to say do nothing is not practical within that
11 first seven days of flight, or three days even. It is just
12 not feasible.

13 Okay, why don't we start down at the end again and
14 come back around.

15 DR. BRACKMANN: You want specifically the question
16 of drugs, primarily?

17 DR. BERRY: Yes, or anything that, if you were
18 sitting in this spot, you think you would do. I guess that
19 is what I am really trying to say.

20 DR. BRACKMANN: I think I would treat them prophylac-
21 tically with the agents that they responded best to on the pre-
22 flight tests. I am not sure what they were. I missed what
23 the primary crew had preferences for, but whatever that would
24 be. I don't know the reason, what specific side effects, or
25 what effects it has, but I think it is beneficial and I think

JB3 1 particularly with the previous history of problems in Skylab
2 3, they are going to be attuned to a possible problem, and
3 for whatever reason, I believe that the drugs would have a
4 therapeutic effect.

5 DR. BERRY: As far as you know, in anything that
6 you can think of right now, you are saying that you do not
7 know of anything better than that right now, that we ought
8 to think in other terms.

9 DR. BRACKMANN: Do you mean other types of drugs?

10 DR. BERRY: No, that you do not have any other means
11 or anything?

12 DR. BRACKMANN: I would say no. As you mentioned,
13 and I think it is almost too late to try, but if they do have
14 some flight time, probably the stimulus which would be best,
15 would be the parabolic, trying to duplicate zero gravity, the
16 loading and unloading of the otolithic structures. That
17 would be all.

18 DR. WOOD: I would treat two of them and let the
19 command pilot do the docking, just in case there was any doubt
20 about side effects. I would give the other two the drugs,
21 unless the command pilot has tried it and wants it. In all
22 of this testing and all of the devices, the human brain is
23 able to rise to occasion, such as when your alarm goes off
24 in the morning and you get up, or when you answer the phone,
25 and be alert during that particular period, and then maybe

1 sink back into bed after you finish the call. People do rise
2 to the occasion and anytime you try to show a drug effect,
3 it falls off.

4 I think the point of knowing their symptoms, and as
5 soon as they feel their motion sickness symptoms, limiting
6 their movements as much as they can, the combination of these
7 two things could be very good.

8 One point. On the adaptation of rapidly acquired
9 adaptation being rapidly lost. It comes up, but the baseline
10 may steadily rise. But a crash program of adapting may send
11 it up and it may last for a few days, but then it drops off
12 almost as fast as it was acquired, with perhaps a slight rise
13 in baseline. So this crash program of adaptation may not
14 last until you get them to the pad -- I don't know. Other
15 than that, adaptation in zero gravity, if you could do it,
16 and parabolic adaptation is good.

17 DR. JOHNSON: Bearing in mind the Russian experience
18 of complete failure, I believe, to produce adaptation by all
19 sorts of acrobatic exercises, I would not recommend any pre-
20 flight adaptation. Once they are moving, I would advise them
21 as to limiting their head movements, but not completely
22 obliterating their head movements, but moving slowly as if
23 one had a sore neck, and when necessary to read anything, use
24 the eyes to look at instruments and push buttons and other
25 things they may do, checklists, but without accompanying that

JB4

1 with rapid head movements. As far as the point ⁷⁴mentioned
2 earlier about the conflict of sensory input between vision
3 and between the vestibular sensations, I don't know if it is
4 too late now, but you might consider locating their checklists
5 in such a way that they do not have to carry out large head
6 movements. I don't know where they are, whether they are in
7 a pocket or what.

8 DR. BERRY: They carry them around in books. In
9 the command module they have them in all kinds of places, in
10 front of them. They carry books around with them when they
11 get into the workshop areas, and sometimes if they are at a
12 console, and they are checking on something, they will put it
13 in front of them where they can see it.

14 DR. JOHNSON: Are they printed or typed?

15 DR. BERRY: They are all printed.

16 DR. JOHNSON: Can they be made in large type so they
17 don't have to strain?

18 DR. BERRY: I am sure they could.

19 DR. WHITE: Too late. Most of those checklist books
20 are already up there.

21 DR. BERRY: A lot of them are. They will take some
22 additional things, but a lot of the basic checklists are
23 already up there.

24 DR. JOHNSON: Anyway, when they do read, I would
25 advise them to use their eyes without accompanying head

JB5

1 motions. I am not in favor of telling them not to move their
2 heads at all. I think they should to bring on the habituation
3 process. Also, I am in favor of this. When the symptoms start
4 to appear, if they find them disturbing enough, they should
5 supplement the head movements with Scop-Dex.

6 DR. BERRY: But you are not saying prophylactically?
7 You are saying wait until you have symptoms?

8 DR. JOHNSON: Yes.

9 DR. BERRY: That is the difference. Now that
10 therapy, not prophylaxis.

11 DR. JOHNSON: They may never need it. Finally, I
12 am still quite a bit interested in vestibular sensitivity
13 changes in regard to potassium changes, in circulation.
14 Whether there is any way you could take a careful look between
15 now and then as to how much potassium or whatever you use
16 to offset the potassium depletion, rather than just giving
17 them massive doses. I would be against that.

18 DR. BERRY: We are not doing that. We definitely
19 are not. What we are doing is using only dietary --

20 DR. JOHNSON: Sufficient to balance.

21 DR. BERRY: Yes, a diet sufficient to balance, right.
22 That is what we are doing now with Skylab. We did some pretty
23 heavy stuff before on 16 and 17, after our experience with 15,
24 but it has been dietary intake and it has been fairly static.

25 DR. JOHNSON: That is good. That is all that I can

1 think of at the moment.

2 DR. BERRY: Dr. Russell?

3 DR. RUSSELL: I go along with what has already been
4 said. My instructions, putting in just a slightly different
5 way, would be that I would discourage any excessive head move-
6 ments, particularly those which are associated with reading,
7 and then let them make the decision as to what they consider
8 excessive, because they know what they have to do. They can
9 just keep that in mind.

10 Though I am against prophylaxis in these types of
11 things, I think until we listen to and redigest what we have
12 heard today so that we can formulate something ahead of time
13 that I would go along with, I think I would put this sort of
14 string on it, because I would not want to hear somebody next
15 time say, well, it worked.

16 DR. BERRY: You are buying that if you go the pro-
17 phylactic way. You are buying the upcome also that you are
18 not really sure whether or not the guy had symptoms, just
19 like what happened with Kerwin. I think that happened with
20 Kerwin, as an example, and you are playing the odds here.
21 You are saying that you are not going to take that risk. You
22 can take that position and say that you do not want to take
23 the risk, and I have already stated that that is the way I
24 feel. Now there are other people, as you can see here, who
25 would say, let us wait until we get it. You heard Garriot

JB7 1 say that is what he would do. He would prefer to wait until
2 he gets it. Now what bothers me about that is that we have
3 never had anybody really do it the way we think it ought to be
4 done, to really medicate themselves properly. No one has. They
5 finally got convinced on the ground that the medication did
6 something for them, by taking the medication and being able
7 to move in the chair. They were convinced, yes, that stuff
8 really does it. But they still did not get convinced enough
9 that they ought to go ahead and stay on some routine. There
10 is an image problem here.

11 DR. JONES: My recollection of flying is that I
12 would not want to take therapeutic agents when I was going to
13 be up several thousand feet at the control of an aircraft.

14 DR. BERRY: Let me tell you, the stuff that they have
15 to do here is not like flying an aircraft. It is not as de-
16 manding. You have not got a crash staring you in the face or
17 anything like that. It is not nearly as demanding.

18 Now there is a carryover, particularly in the
19 commander's position. He is worried about a burn, an SPS
20 burn and this sort of thing, critical burn, a critical docking
21 maneuver and this sort of stuff. They have got some worry
22 about that, and we have trained them that way. Let's face
23 it, it is our fault. For years we have told them if they were
24 going to fly, don't take anything. No drugs while flying.
25 That has been our credo for so many years, and now we are

1 turning it a_round and reversing ourselves, and they say, wait
2 a minute. They don't know whether to believe you or not.

3 DR. WHITE: But basically your first statement is
4 true. The bordering on disaster of high altitude flying,
5 the high performance aircraft and what they are doing here is
6 different.

7 DR. JONES: The thing I was thinking of as a situa-
8 tion would be the GCA approach in fog.

9 DR. WHITE: But they don't really have anything like
10 that.

11 DR. BERRY: You want them to be reliable, you want
12 them to be confident that they are reliable in performing and
13 performing on schedule, but it is more that kind of thing,
14 more of a managerial function, rather than the criticality of
15 control.

16 DR. RUSSELL: I think you have to be proper because
17 you have used the terms properly informed and management and
18 so forth, but they are the people who have the feelings, and
19 I would not like terribly to take that decision out of their
20 hands. I still hesitate, although I am giving this thing
21 ahead of time, because I am not so sure that it might not
22 make them sicker.

23 DR. BERRY: We had better know that before we put
24 it to them. You would never give it without knowing that.

25 DR. RUSSELL: But you will never know.

JB9

1 DR. BORISON: You will never know what happens in
2 space, in advance. You may know about side effects, about
3 what not to do. You simply do not know what you should do.

4 DR. WOOD: Another point I would inject. You never
5 had anyone completely wiped out with motion sickness.

6 DR. BERRY: Yes, we have.

7 DR. WOOD: If you do, the oral does not do any good.
8 Rectal suppositories may help.

9 DR. BERRY: I just brought that up and I think that
10 is an interesting point. If you let somebody get that far,
11 you could really be in trouble. Of course, that was our
12 early worry. The only thing we have injectable on there I
13 would not want to use, because I don't think it is worth a
14 damn, and that is Parasine.

15 DR. JONES: I like to think in terms of a compromise
16 between Walter's suggestion and Jack Schmitt. I seemed to
17 me that Jack Schmitt had his own case very well wrapped up.
18 The approach would be to take one's self well below what he
19 called his threshold, and treat one's self either by resting
20 or therapeutically, but never let one's self get past the
21 point where actual overt vomiting would have to take place.
22 If I remember right, he put forward the view that a reasonably
23 intelligent and responsible astronaut ought to be able to
24 be trained to handle his own therapeutic treatment, but it
25 would be necessary to train them.

JB10

1 The reason finally that I go partly with Walter,
2 who recommends against absolute bed rest, and you know the
3 reasons why I think you should not do that, but I would go
4 beyond them on the grounds that, to me, the habituating pro-
5 cess is not linked purely to the sensory input, but to this
6 relationship between sensory input and the consequent motor
7 control. The motor control in this case is getting around your
8 new space environment, going through the hatches, down into
9 the workshop. To my way of thinking, if one is going to spend
10 the first three days coddling one's self, and not undergoing
11 that kind of activity, he is going to have another three days
12 learning how to handle that. So that one can only hope to
13 prolong the agonies, or in practical terms the loss of useful-
14 ness, the lowering of efficiency, by failing to take one's self
15 steadily up towards one's limits, in the same way that a diver
16 will bring himself up from depth on the basis of the knowledge
17 of arriving close to his limit, his bends limit, either calcu-
18 lated or experienced. He is going to get to the top quickest
19 if he keeps himself nearest his limit, without allowing himself
20 to go past his threshold.

21 DR. BERRY: Astronauts are notoriously lousy, as are
22 pilots, at knowing what their limits are.

23 DR. JONES: Is it possible to train them?

24 DR. BERRY: These guys have some training in this
25 particular area, where our other crews have not because of

1 the experience, and all three of them will have had some
2 experience this time.

3 DR. JONES: The last point I would make would be to
4 reinforce yours, that unless one does allow the individuals
5 to take themselves towards symptomatology, one is going to have
6 no further knowledge around as to what the time course of
7 habituation to zero gravity environment really is.

8 DR. BERRY: Ash?

9 DR. GRAYBIEL: Obviously we are dealing with trade-
10 offs. There is one phase of this that is not involved in a
11 tradeoff, really, and that is the educational phase. I feel
12 very strongly that these people should spend more time maybe
13 sitting around a room and learning something about the elicitat-
14 tion of motion sickness, its time course, the different environ-
15 ments, the use of drugs and so on, than let us say flying all
16 of the time. I think it has a much bigger payoff.

17 I don't know how much they will sit still for, but
18 I think it should be pointed out that there often is a con-
19 siderable latency between the elicitation of the head movements
20 and when the buildup in symptoms comes. If they are going to
21 stay on a strict temporal basis, and they learn this in the
22 chair in a way that is not very good, where they quickly get
23 symptoms or they do not -- that is settled right away -- but
24 in an environment such as they are in there is considerable
25 latency. I think that they should understand this, and

JB12

1 maybe the emphasis should be that they should watch for the
2 very earliest symptoms, and then, insofar as it is feasible
3 to stop the head movements, let them recover a little bit and
4 then go ahead with the drug. I think that when they first
5 go up there, suppose you let Pogue ride, just to try the fact
6 that he is relatively insuceptible as compared to the others,
7 and I think I would not give him the drug right away --

8 DR. BERRY: We cannot win our bet if we do anyway.

9 DR. GRAYBIEL: That was in my mind. But with the
10 other two, I am inclined to give them drugs to make the transi-
11 tion, and then I think that I would certainly not give them
12 more than two pills, let's say, the first day, and then wait
13 and see how things go on. They may have enough carryover to
14 take them the rest of the day. If they need another pill, okay
15 take it. Then it may be that on the second day, if they are
16 really careful and watch themselves, and realize that very
17 mild symptoms of not feeling very well or some loss of appetite
18 the symptomatology that both Rusty and I think Joe had, and
19 he almost agreed to it. This would be very interesting because
20 then, if you take a pill, you ought to get an effect pretty
21 soon, and it would have a therapeutic trial diagnostic feature,
22 you see, and Joe, himself, felt that this would be an okay
23 thing to do. So this would test the proposition that, yes,
24 these symptoms were symptoms of motion sickness and they are
25 being relieved.

1 So I guess in a way this is kind of a compromise
2 between the two. In a way it is prophylaxis, but at a very
3 sensitive level, to go ahead and administer the drug. They
4 may just need it for two or three days.

5 DR. BERRY: I would think more than two or three
6 days.

7 DR. GRAYBIEL: Yes, you see they will do more head
8 movements with the drugs. If these other people had taken the
9 drugs the first two days, they would have been home free.

10 DR. BERRY: Let me tell you, that they got into a
11 depression that was very interesting.

12 DR. GRAYBIEL: Very interesting, and one character-
13 istic of that that we called that soap-eyed(?) syndrome where
14 they have not really got a lot of active nausea and vomiting,
15 but they just are dull --

16 DR. BERRY: They were definitely depressed. Then a
17 second thing happened to them. They knew that they were so
18 far behind on everything that it was obvious to the ground and
19 to the world. This was going out every day to the world, and
20 they knew that, and here they felt they were not producing.
21 What's the matter with us? And then they began to get a feeling
22 of guilt and they got a guilt complex about it. Look at what
23 we have done, and look at what those last guys did compared
24 to what we are doing, and that is terrible. They got so far
25 behind they tried the whole rest of the flight to make it up,

1 which is what they did, and they more than made it up. They
2 worked like hell for the rest of the flight, and it was very
3 interesting to see that whole series of things happen. They
4 even got some body consciousness. Garriott, in particular,
5 which is very interesting, became very body conscious in that
6 same period.

7 All of those things added up, to me, say that that
8 is not a good situation to find yourself in if you can avoid
9 it, and that is what worries me. It was a whole series of
10 things that just compiled their problem and made that first
11 week. It is easier for Owen to sit here and be a lot more
12 cavalier about what happened that first week than it was at
13 that time.

14 DR. GRAYBIEL: Read the tapes.

15 DR. BERRY: That is right. If you just read those
16 post-flight tape, even immediate post-flight, things were bad.
17 But even then they were not as bad as they really were before.
18 If you had a tape of that very first weekend flight, it's an
19 entirely different thing. If you go back and look at just
20 the air-to-ground transcripts, the stuff that was in the open,
21 you do not have to read very much to know that those guys were
22 in deep depression that first week. There is no doubt about
23 it. When you have a crew that reacts the way those guys did
24 and the things that they were willing to say, that without
25 any doubt they could not hack it, they could not do any more,

1 that they were moving as fast as they possibly could safely,
2 that there was nothing else they could do -- and it was that
3 kind of thing all the time, and apologizing all of the time --
4 so that is a very interesting series of events compared to
5 what we had seen in the previous flight. It was an entirely
6 different reaction.

7 We all forget. We can remember the good things with
8 time, and they do the same way. We used to have trouble with
9 them even remembering what they had done on the first day of
10 the flight when there were only 12-day flights. These guys
11 did almost 60 days. That is a long time, to remember what
12 happened to you four weeks ago or eight weeks ago. That is a
13 hard thing. I don't even remember where I was eight weeks
14 ago, let alone what happened to me. They can say where they
15 were because they were stuck in space.

16 Okay -- very good.

17 DR. BORISON: My feeling is that there is too much
18 confidence being put into drugs. I think it is a big invest-
19 ment you are making, and when it comes to the crunch, you are
20 going to be disappointed. Perhaps for their psychotropic
21 effects this may be valuable. I do not think there is a good
22 anti-motion sickness remedy at the moment, because we do not
23 understand the mechanism and I think you have to understand
24 that first. We are just doing that empirically and we are
25 hoping for the best. I would not throw it out, but I would

bowfls 1 say use it for what little benefit you may be able to get
JB 2 to take the edge off your psychotropic effects. I would put
3 my money on the physiological approach and see what could be
4 done with unloading the otoliths before they go into their
5 flight, and maybe having on hand a device that would reload
6 the otoliths -- I am sorry, unload the otoliths again once
7 they get back on terra firma. In other words, at least you
8 could do these two things on the ground maybe using a device
9 as I suggested of a sawtooth type of movement.

10 I would say if you want to take a gamble, if you
11 could get an on board seat of some sort that would oscillate,
12 and you could control this oscillation in either direction,
13 a sawtooth up and a sawtooth down, I don't know if there is
14 enough time for that sort of thing, but certainly trying to
15 do it on the ground, maybe even by the time they get back,
16 and see if you could not in fact by preventing the reloading
17 of the otoliths when they are being debriefed, something of
18 this sort, to see if you could not ward off the onset of
19 motion sickness again on the ground.

20 DR. BERRY: I would like to hear you and Dr. Wood
21 argue. You don't think there is an effective anti-motion
22 sickness drug.

23 DR. BORISON: No. Look at the Navy. After all,
24 they would love to have an effective anti-motion sickness
25 drug.

1 DR. BERRY: Have you ever had any experience with
2 the Scop-Dex combination?

3 DR. BORISON: No, I have not, but I will tell you
4 what we teach our students. Never use drug combinations by
5 mouth.

6 DR. WOOD: Our best recommendation for this are the
7 nurses at the hospital down there, who go deep sea fishing.
8 They take it routinely.

9 DR. BERRY: I will stand up for them.

10 DR. WOOD: They come out pretty well. No drug is
11 perfect. It raises the threshold, and that is its limitation.
12 If you exceed that threshold, they are going to get sick.
13 If they have a very sensitive person, sometimes it merely
14 delays it. I will grant you there is no perfect drug. Yet
15 if you raise the threshold enough to get over your stimulus,
16 then you may have a pleasant trip as opposed to one that
17 you are leaning over the rail.

18 I think on the centrifuge there we can show that
19 you can adapt someone or habituate them, or you can give them
20 drugs. You can go from something like 50 head movements to
21 300, 50 head movements with them getting sick, and 300 head
22 movements with them not getting sick with the drugs. So the
23 drug I grant you is not perfect, but it does raise that
24 threshold enough so that it may be the difference between
25 a pleasant trip and an unpleasant one.

1 DR. BORISON: But to be very hard nosed about it,
2 I have to ask the question is this clinical impression, or
3 does this stand up to statistical evaluation, that is to say,
4 does it fulfill all of the criteria of a good clinical
5 pharmacological experiment?

6 DR. WOOD: I think we did. We used double blinds.
7 We have done some six or seven experiments using 10 subjects
8 each in each of the 10. So on this basis, yes.

9 DR. BORISON: Yes, for your experiment, but how
10 about for space flight, for what we have heard today? So
11 okay, we don't know that it applies.

12 DR. WOOD: You can never answer that question until
13 you get your space shuttle and try it up there.

14 DR. BORISON: But were they valid statistical
15 samples?

16 DR. WOOD: Yes.

17 DR. BORISON: Now, in the field, in Navy experiences,
18 has a good anti-motion sickness drug actually been found?
19 Does Scop-Dex really work?

20 DR. BERRY: What are you using in the Navy, Ash?

21 DR. GRAYBIEL: Well, they are not using anything
22 much in the way of anti-motion sickness drugs. They have
23 had a meeting recently under FASEB auspices, and I think that
24 they are going to probably do something about motion sickness
25 due to vibration, particularly around one hertz, or shorter

1 oscillations. It is true, they have not been very enthusiastic
2 but we do have a lot of enthusiastic customers on a single
3 basis. I answer telephone calls from all over, people who
4 sail and are in sailing races and different things like this.
5 They have tried all sorts of different things, and between
6 Promethazine and Scop-Dex, we have done a pretty good job of
7 satisfying them. Of course, the local people in Pensacola,
8 they are familiar with them, and I think that they would say
9 that they work.

10 I think motion sickness is probably rather similar
11 if it is brought on at about the same rate, regardless of the
12 motion involved. In other words, just because we have tested
13 the drugs in a slow rotation room does not mean that they are
14 not effective for sea or air. We know they are. We know
15 already that they are effective in space. You only have to
16 ask the astronauts. Their criticism really was why didn't
17 you tell us to take more pills, really.

18 DR. WOOD: When I go fishing for the first time, I
19 take double that dose of Scop-Dex.

20 DR. BERRY: That is another problem. The doses that
21 have been used down there were double that dose, really, 10
22 milligrams and .64, right?

23 DR. GRAY: That is what we started out with when
24 we were doing this, too, but the double dose is not that much
25 better than the single dose.

1 DR. WOOD: I realize that, but your effective blood
2 level, you may just be at the level that is giving an effect,
3 and if you double it you are much safer. If I am going on
4 board a boat, I am going to take the double.

5 DR. GRAYBIEL: All right, for one day, for a limited
6 period of time, but if you are thinking of three days, I can
7 tell you that I don't know too much about Scop-Dex, but I
8 would say that Promethazine in ephedrin, that first double
9 dose that we took, this was really too much, I think, with
10 another dose coming along in four hours.

11 DR. BERRY: We are really up against it. If these
12 two guys end up saying that they want to use it, as it appears
13 they do -- they want to use that Promethazine-Ephedrin combi-
14 nation. We have that made up at the 25 and 50 now the way
15 that it is, that combination. We are not going to have time
16 to run them on two three-day trials. We are going to have
17 to run them on one three-day trial. So we have got to
18 decide what we are going to use for that dose if those guys
19 decide that is the thing they want to use.

20 The Commander, Jerry Carr, first thought he did not
21 want to use Scop-Dex, but he now has come up with the feeling
22 that he does want to use Scop-Dex, which surprised me. He
23 tried the Promethazine and he has gone back to Scop-Dex,
24 which surprised me, really.

25 DR. GRAYBIEL: I was a little bit surprised. I had

1 the feeling that we probably were going to wind up our little
2 experiment in favor of Promethazine, but I think it was almost
3 entirely due to the spacing of the doses or the strength of
4 the doses. I think the first dose was real fine, but it was
5 the second dose --

6 DR. BERRY: It is amazing. We ought to just wait
7 and run it out to six hours, is what you are saying.

8 DR. GRAYBIEL: . If I were going to use it that
9 way right now, I would use it, let us say, every six hours.
10 On the other hand, I think probably to put the amphetamine
11 in there, although you say that it has an action as long or
12 longer than the ephedrin.

13 DR. WOOD: Yes, and the Scop now has an action
14 that is limited to about four hours, so that is very important.
15 I think that is one of the reasons our studies did not find
16 Scop very good going across the Atlantic on the troop carriers.
17 They gave it every six hours, and here they were not protected.
18 The British on short term found it was great.

19 DR. GRAYBIEL: So did Jack. He had to have it, you
20 know, pretty frequently.

21 DR. RUSSELL: Can you use 2.5?

22 DR. WOOD: I think you do need the 2.5. The
23 amphetamine now, yes, you would need it, but it lasts longer
24 than the Scop. I think its duration is longer. That is the
25 reason it is matched with the Promethazine. But the

1 amphetamine builds up, and of course the amphetamine has a
2 sort of lifting effect. There is a central effect to that.
3 They feel better about the thing.

4 DR. BERRY: There is a depression that goes with
5 motion sickness. I think there is no question about it.
6 You do get depressed.

7 DR. GRAYBIEL: Especially the prolonged exposure.
8 We found in the slow rotation room, when you get something
9 acutely, you get over it acutely and quickly. But they sit
10 in there hour after hour, and this is when they had -- we
11 had them experience symptoms not too unlike what some of the
12 astronauts have talked about.

13 DR. BERRY: When do you get the first one, Dr.
14 Graybiel?

15 DR. GRAYBIEL: The astronauts felt that they needed
16 40 minutes. First they said an hour to an hour and a half.
17 Then when you pressed them a little bit, they said well, maybe
18 40 minutes to an hour. I think that you get a notion that
19 you are absorbing Scop-Dex if you are not motion sick in a
20 matter of 20 minutes. I can feel, for example, the
21 amphetamine within 20 minutes, and begin to get a little
22 dry mouth within 30. But you can't be sure just what it would
23 be there. So I think that an hour is very safe as a time,
24 and not too much is known about all this absorption of drugs.
25 Just like the time course, there is not very much known.

1 DR. BERRY: It is amazing to me how little we do
2 know about that.

3 DR. GRAYBIEL: It is incredible how little. There
4 are some measurements being made, and we are going to get
5 some measurements.

6 DR. BERRY: We have had the question raised, and
7 I think it is very interesting, that people feel they got the
8 effect in the same time frame in flight. That is a good data
9 point to say that they got the effect in the same time frame
10 in flight that they do on the ground, because one of the
11 questions that we have been asked repeatedly, everybody says
12 you are using drugs and you don't know what the effect is
13 going to be in flight. I turn that around and say you don't
14 know what the effect is on the ground. You don't know what
15 is happening with it on the ground. You are telling us we
16 don't know if it is going to be absorbed differently. They
17 don't even know that on the ground, let alone in space. So
18 I don't think that is a real criticism of the situation.
19 I think the best thing you can do is if a guy has had it on
20 the ground, and he has had it there, they do feel their
21 stomach contents ride up and this sort of thing, and then you
22 say you have altered circulation. Yes, you do have altered
23 circulation, and you have in some ways better circulation.
24 You have some fluid changes which then alter the drug, too.
25 There is no question about that. But all of those things I

1 think have to be learned, and we have to try it.

2 DR. GRAYBIEL: And if they would be willing to even
3 communicate more with JSC. I think they will pay a little
4 more attention. For example, a few flights ago you could not
5 tell them anything, and we have come a long way.

6 DR. BERRY: We have come a long way.

7 DR. WOOD: I would not give the Promethazine every
8 four hours, though.

9 DR. BERRY: If you gave the first one an hour after
10 takeoff, then you give the second one prophylactically at
11 six hours.

12 DR. WOOD: In fact, I think you would be safer at
13 eight hours with that drug, but Scop is a four hour drug pretty
14 much.

15 DR. GRAYBIEL: Yes, we demonstrated a pile-up with
16 Promethazine and ephedrin.

17 DR. RUSSELL: How many are you going to give
18 prophylactically? I am not clear?

19 DR. WOOD: I would give Scop every four hours
20 prophylactically.

21 DR. RUSSELL: Three, four, five times?

22 DR. BERRY: I guess we can conclude this meeting
23 now.

24 (Thereupon at 7:15 o'clock p.m., the meeting was
25 concluded.)