in the indicated numbers of trials. Training on the sixth (smallest) pair was terminated after 3000 trials, within which period this animal had performed at 90 percent or better on several individual days but never on three consecutive days.

To date, the lesions of animals S-6 and R-1 have been evaluated histologically. These cats had survived postoperatively for 16 and 12 months, respectively. In both animals removal of the lateral and posterolateral gyri was complete into the depths of the adjacent sulci. The dorsal lateral geniculate nuclei showed profound retrograde degeneration with gliosis in all laminae. Scattered normal-appearing neurons were seen throughout the nuclei, confirming the observations of previous investigators. The lesion of cat S-11 is complete, as revealed by gross examination. Animals S-8 and S-12 are still alive; the lesions in these animals were judged complete at the time of operation.

This study shows that adult cats can be trained in a conventional apparatus to discriminate between an erect and an inverted triangle at a high level of performance after removal of cortical areas 17, 18, and most of 19. Discrimination of figures such as these has in the past constituted evidence for the ability to discriminate visual forms. It should be noted, however, that although the total luminous flux was equated for the positive and negative stimuli, differences in the spatial distribution of flux between members of each pair were present throughout the series. This difference in the distribution of flux between erect and inverted triangles may be significant to these results since adult visual-decorticate cats can perform a discrimination based on differences in total luminous flux between two stimuli (*10*). To what extent the mastery of this discrimination represents a conceptual response to form per se (that is, triangularity of the stimulus in these studies) must therefore await further studies of the discrimination capacities of these animals.

The results presented here indicate that information about the spatial distribution of light, within areas equated for the total amount of light, can be utilized to direct purposeful behavior by areas of the brain other than cortical areas 17, 18, and most of 19. A clue as to the location of such other areas may be provided by recent evidence for "extrastriate" projections of the dorsal lateral geniculate nucleus of the cat.

As noted above, complete removal of the lateral and posterolateral gyri does not result in complete degeneration of the cells of the dorsal lateral geniculate nucleus (LGN_d). Evidence that a portion of these remaining cells project directly to the suprasylvian and ectosylvian gyri has been presented by Glickstein *et al.* (*11*), who demonstrated Nauta-stained degenerating fibers terminating in these gyri (entirely outside visual areas 17, 18, and 19) after discrete lesions in the LGN_d of cats.

In light of both our behavioral evidence (following removal of the visual area) and the anatomical evidence cited supporting projections of the LGN_d to cortex other than the visual areas, it is reasonable to suggest that the results of earlier behavioral studies indicated a severe deficit in visual form discrimination not because the striate cortex (area 17) alone is capable of mediating such a discrimination, but because the lesions made in those studies removed all of the cortical projections of the LGN_d, to both striate and widely distributed extrastriate areas. In the present study, confinement of the lesioned area, the unlimited length of training, and training through a graded series of stimuli may all be significant determinants of the results, which show that the histologically defined striate cortex is not essential in the cat for mastery of a visual discrimination based on the spatial organization of light.

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15 August 1967

Sky-Hook: Old Idea

I would like to make a few more observations on the "sky-hook" (*1*). In 1895, the Russian pioneer of astronautics Konstantin Tsiolkovski first considered the possibility of an object's withdrawing from the earth with the aid of a rigid structure ("tower") that would extend upward at right angles to the earth's surface (*2*).

Tsiolkovski wrote: "On the tower, as one ascends it, gravity decreases gradually, and if . . . erected on the equator, then gravity will decrease not only due to removal from the planet's center but also due to the proportionally increasing centrifugal force . . . On climbing such a tower to a height of 34,000 versts [1 verst = 1.07 km], gravity will disappear, while still higher there will again appear a force that will increase proportionally to removal from the critical point, but acting in the opposite direction . . ." Thus Tsiolkovski outlined the basic scheme for the cosmic lift.

A height of 36,000 km is that required for a stationary satellite; the force of gravity is equal to the centrifugal force and the orbital time is equal to the period of axial rotation of the earth. In 1960, the Leningrad engineer Y. N. Artsutanov presented an idea similar to that of "Tsiolkovski's tower," giving it a different design and mechanical embodiment (*3*).

Artsutanov began with a 36,000-km stationary satellite. Extending straight up and down from the satellite are lengths of cable. The lower end of the cable is secured to the earth's surface. The whole system—stationary satellite and upper and lower cables—forms an integral unit and rotates at the same angular speed as the earth. The system is constantly taut, for at any point above 36,000 km, the centrifugal force exceeds the force of gravity. The upper end does not need to be anchored. It would be hung, as it were, on a "sky-hook."

Artsutanov's paper also deals with the strength of the cable. Obviously, the tension experienced by the cable is extremely great. More importantly, the tension of the cable would be greater at points closer to the stationary satellite. This means that a cable of variable diameter could be used, thin at the earth's surface, and gradually thicker toward the satellite. Further upward it could again be thinner. Artsutanov calculated that a cable weighing 1 g/meter and withstanding a tension of 1.5 to 2 tons would meet the requirements of a cosmic lift. The minimum diameter of the cable at the earth's surface would be about 1 mm, and the total mass up to a height of 50,000 km would be about 900 tons. Building materials with the required characteristics have been obtained in laboratories, although only in microscopic amounts.

Naturally, to make the cosmic lift work, a source of energy is required. However, this energy would have to be expended only on the lower section of the path—from the earth's surface to the stationary satellite. Above this level, the centrifugal force would exceed the force of gravity, and the load would ascend by centrifugal force. Any moving mass has energy, and, in its upper path, the cosmic lift, far from consuming energy, would itself become a source of energy.

This energy liberated by the lift can be used in different ways. First of all, it can be used for space flights. The energy developed over the upper section—above 36,000 km could be fed to a power station supplying the lower section of the lift. This would result in an interesting situation. The expenditure of energy for ascending the "cableway" to outer space could be reduced to a minimum. According to Artsutanov's calculations, a height of 144,000 km can be reached without wasting any energy at all. The amount of work obtained along the upper part of the path would equal that spent along the lower part. At heights greater than 144,000 km, operation of the cosmic lift would turn into pure profit. The lift would become a sort of power station.

The capacity of the heavenly funicular would evidently be limited by the strength and dimensions of the structure and also by the speed of the loaded car. The strength of the suspension could be increased a thousandfold by strengthening the initial cable. The speed should be about 1000 km/hr. Then it could handle about 500 tons an hour or 12,000 tons a day. A lift with a capacity of 500 tons an hour could convey 360,000 tons to the upper platform in a month. This would make it possible to assemble and equip 20 space liners of 30,000 tons each. These spaceships could start off from a height of 47,000 km with their engines idle, solely through the action of the centrifugal force caused by the earth's rotation. Such lifts could conceivably be built on the moon, Mars, the asteroids, and other planets.

Exactly when it will be technically feasible to build space lifts, it is hard to say. Such a project may possibly get underway by the end of this century.

We in the Soviet Union have read the paper of Isaacs *et al.* with great interest. It testifies to the fact that ideas are "in the air." Analyzing the investigations of Isaacs *et al.*, we do not find any new elements, as compared to Artsutanov's published 6 years earlier. I also assert that the "sky-hook" problem has been dealt with in greater detail in Artsutanov's paper. This inclines us to stress his priority in this field. Our attitude toward priority is devoid of chauvinism or nationalism. We welcome international ties in science and believe that the "sky-hook" project affords a good opportunity for the cross-pollination of ideas in science.

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17 August 1967

We have read Lvov's discussion of Tsiolkovski's work and Artsutanov's ideas with interest. We have also inspected a copy of Artsutanov's newspaper article to which Lvov refers (Sunday–Special Supplement of the Komsomolskaya Pravda, 31 July 1960). The article clearly demonstrates that Artsutanov proposed the "sky-hook" development some 6 years before our paper appeared in *Science*.

Artsutanov's article presents none of the calculations or results on cable diameters, strength, energetics, traffic capacity, and a number of other factors to which Lvov alludes. Presumably Lvov has also had access to studies of a scholarly nature that Artsutanov has prepared, although no reference is made to these.

In his article, Artsutanov is far bolder than we, as he foresees an immense development of routine and scheduled space commerce on "heavenly funicula" (a term we applaud). Our proposal is modest and is concerned with the immense engineering challenge of the possibility. Nevertheless, we also believe that developments based on the principles of "sky-hook" may indeed become important realities.

We hope that Artsutanov derived as much excitement and enjoyment working on the idea as we did.

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Continental Drift and Spreading of Ocean Floors

Shapiro's footnote (*1*) on the use of radar interferometry to measure present-day continental drifts deserves several comments. Although negative results with such an interferometric system would not preclude relative continental movements at some time in the past, positive results would irrevocably settle the dispute regarding the feasibility of such movements—something that more conventional approaches have yet to do. Positive results that were geographically extensive might greatly enhance our understanding of the development of continents and ocean basins. With regard to ocean basins, positive interferometric measurements from oceanic island–based receivers could resolve at least one major controversy (*2*) in the hypothesis of spreading of the sea floors: Is spreading taking place today? Furthermore, data from base lines having both continent- and oceanic island–based arms might give us rates of movement between ocean floors and continents. Such data could greatly clarify any relation between spreading of the sea floors and relative continental movements.

It is time for us to begin active pursuit of the enormous potential of these techniques in some well-coordinated fashion. It would be more than appropriate if such coordination were thoroughly international in spirit and practice.

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