the car (ski) turn. In Fig.14, only one snow ski is drawn. The skier is making a straight descent on the snow plane with the inclination angle of α. To stop at point K, the skier makes a rapid left turn and stops the skis while skidding.

The skier's sense of making a ski turn is a "*human illusion*," as we expected. It was a happy coincidence for me that the driver did not brake at point K in Fig.13, but instead made a sharp turn there. I attempted to experience the same phenomenon thereafter; however, at most intersections, the bus first reduces its speed by braking and then makes a turn; therefore, the centrifugal force is usually small and a similar phenomenon could not be experienced. A few years later, I conceived of a different idea which I published in paper Ⅲ.[9] I will cite it below.

Car passenger's sense of turning

Assume that you are sitting in a car next to the driver, with your legs extended and feet placed on the floor, and with separation between your knees and the seat (Fig.15). Let us examine how your knees will move if the car makes a left turn (Fig.16). Your knees are in front of your body while the car is traveling straight ahead (Fig.16a). When the car begins to make a left turn, your knees move downward and to the right due to centrifugal force (Fig.16b). Therefore, when the car is turning left, you will make your knees twist to the left, using your feet for support, so that your knees do not move downward and to the right (Fig.16c). You will feel that *the twist of your knees (i.e., muscular strength) made the car turn left* even though your knees were apparently stable. Both cars and skis are types of vehicles. Let us now change the vehicle under consideration from a car to a ski.

Problems related to skier's perception

Let us assume that *the turning descent of a ski* occurs to the left, as determined by the edging angle β_0. At the occurrence of the turn, the skier executes *a twist of the body* to the left, using his feet as supporting points, so that he will not fall down. Here, *the turning descent of the ski* determined by β_0 is the cause of the turn, and *the twist of the body* is the effect. (In terms of time, *turning descent of the ski* and *twist of the body* occur simultaneously. If not, the skier will fall down.)

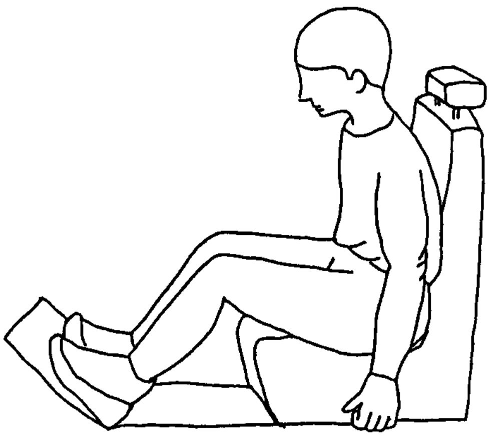

Fig.15 Side view of the in-car experiment on the sense of making a ski turn in the passenger seat.

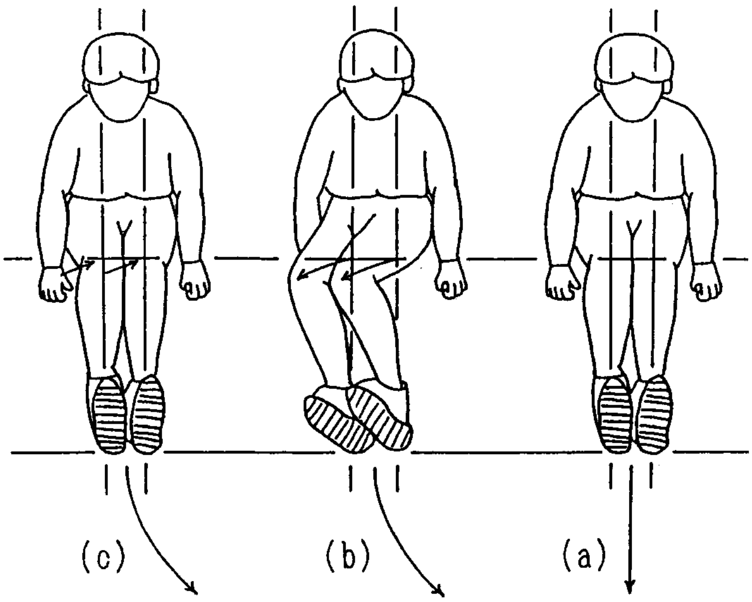

Fig.16 Front view of the in-car experiment on the sense of making a ski turn.
(a) Subject while the car travels straight.
(b) As the car turns left, the knees of the subject move downward and to the right.
(c) When the car turns left, the subject twists his/her knees to the left, so that his/her knees do not move downward.

However, the skier will feel that *the twist of the body (i.e., muscular strength) made the ski turn left.* That is to say, the skier feels that *the twist of the body* is the cause of the turn, and as an effect, *turning descent of the ski* occurs. Let us assume the opposite cause-effect relationship to the one felt by the skier. Here, *turning descent of the ski* determined by β_0 is the cause, and *twist of the body* is the effect. This assumption shows no discrepancy with our results obtained in experiments using skis or a car. When we use a model ski or an iron-plate ski, the ski does not tip over without twist of the body, because the center of gravity is low. When a skier ski is used, the skier will fall down without *twist of the body* since the center of gravity is high. *The skier's sense of making a ski turn* described in the introduction might be *a problem related to the perception of the skier, who mistakes cause for effect.*

Practice of ski turns should therefore consist of drills in simultaneously effecting *creation of angle β_0 and twist of the body.* (End of citation)

The model ski we used is the sand ski used in the indoor experiments described in Sections 5 and 6. The iron plate placed on the iron-plate ski is a 20-kg weight, which simulates a skier, as described in Section 7. The car is a common vehicle. A road with S-curves can easily be found if we drive up a mountain. When we perform car experiments on a road with a number of successive S-curves with a length of 20m, we can feel as if we are making parallel turns. "*When we twist our knees to the right, the car turns to the right, and when we twist our knees to the left, the car turns to the left;*" this situation gives us a wonderful illusion of parallel turns. I recommend readers to try this in-car experiment (Fig.16).

9. Conclusions

As described above, some problems are found in conventional ski theory; this may be because the problem of skier's perception is a part of such ski theory. The causes of the skier's perception, and the actual dynamics of ski motions disregarding the skier's perception must be further clarified by ski researchers through further experimentation.

At the beginning of this article, we described the history of skiing and discussed the problems in ski research. Then, we described that (1) ski turns are determined by the edging angle β_0, and (2) that the sense of making a ski turn is an illusion.

Why do skis turn according to edging angle β_0 ? Why does the sign of β_0 (positive or negative) determine uphill turns and downhill turns ? In this article we described sliding descent without skidding (with only slight skidding). What is the difference in descent between that with skidding (significant skidding) and that without skidding ? Many problems remain unsolved. In the next paper, we plan to introduce the locus of our ski research and examine the above issues.

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