2-Skate-Single-Track-Vehicle without Fork-Angle, Trail or Power: Tested for Rideability, Phase-Lag and Steady-State-Lean-Angles

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Abstract:

A 2-Skate, short for a Two-Inline-Ice-Skates-Single-Track-Vehicle, was built to show that without wheels, gyroscopic effects, fork angle, trail and power-to-the-wheels, a person could ride it. But the rider might have been a circus acrobat that can also sit backwards on his bicycle handlebar, and pedal while juggling and turning around in circle. So the present study aimed at determining if ordinary persons can ride the 2-Skate with confidence, with the same phase lag between torso and vehicle leaning when slaloming, and the same torso and vehicle lean angles in steady state curves as predicted. A protocol was designed and 12 riders tested the 2-Skates. With the exception of a 79 year old and on their first trial, they could ride it and go slaloming. Three did the phase lag and lean angle tests and obtained similar results, confirming the prediction of the Torso-Arms-Handlebar Steering Theory first presented by Ethier (1974), with differential non-holonomic and servomechanism system equations, and further explained on the web with access to recently revised equations. This confirmation (a) sheds light on how bicycles are steered, (b) clarifies that Countersteering is done automatically at low speeds, (c) supports and clarifies the way mountain bike steering is taught, (d) suggests a slight modification of the way motorcycle Countersteering is taught, (e) can be used to develop a different approach to 2-Wheeler simulators, (f) and can renew interest for motorcycles with seat belts and protective structure like the BMW-C1, and the closed-cabin electric motorcycles like the ultra-low drag and award winning Peraves e-Tracer.

Introduction: The rider of a single-track vehicle grips the handlebar, which constitutes the Torso-Arms-Handlebar or TAH mechanism. The torso leaning left of the vehicle chassis, naturally turns the handlebar to the right, due to the arms acting as links to the handlebar (Motorcycle and Bicycle Steering, retrieved February 26, 2023 [https://dynamik23.com/home-2/2wheels/]).

This mechanism constitutes the detector between torso-angle and chassis-angle of a torso-chassis follower servomechanism: Above a minimal speed with the rider staying upright and the vehicle falling right, the handlebar thus naturally countersteers the handlebar to the right, generating a centrifugal force to the left, which brings it back to vertical. This explains the stability at slow speeds as soon as the hands are put on the handlebar: there is no need for gyroscopic reactions to build up with speed. And when the rider leans left to

Figure 1. Rider leaning to his left naturally turns the handlebar to his right
go left, the TAH mechanism naturally countersteers the handlebar to the right. The centrifugal force to the left leans the vehicle to the left, past the torso leaning, until the handlebar naturally countersteers to the left which steers the vehicle in the correct direction.

This natural control of the handlebar constitutes the TAH Steering Theory, first exposed by Ethier (1974), first published by Ethier (2000), and actually further explained on the web (Accessed February 28, https://dynamik23.com/home-2/2wheels/). Many other steering theories exist among which: (a) The Countersteering Theory itself, by which the rider voluntarily countersteers only above speeds of 19 KMH (12 MPH), says a Google Search with keywords “At what speed do you countersteer on a motorcycle”, (b) Keeping balance with torso leaning right or left. (c) Gyroscopic reactions. (d) Front fork geometry, fork angle and trail. (e) “Follow your line” in mountain bike trails… But these theories fail to explain: (a) why there would be a minimal Countersteering speed, (b) why nobody in the road bicycle or the mountain bike communities ever teach or voluntarily applies Countersteering as is taught in the motorcycle community, (c) why the stable speeds with hands ON the handlebar is much lower than OFF the handlebar…

Around 2001, a 2-Skate (short for Two-Inline-Ice-Skates-Single-Track-Vehicle) was built to show that without the wheels, fork angle, trail and power to the wheels, such a vehicle was still rideable because the TAH mechanism was still present. Ethier’s web site further shows that removing the mechanism leaves nothing to hold up the vehicle, which automatically falls (2.7 Isolating factors affecting steering, using a 2-Skate, accessed February 28, 2023 https://dynamik23.com/home-2/2wheels/proofs/#Isolating-factors-affecting-steering). But well trained circus acrobats can sit on their handlebar and pedal backwards while juggling with five balls. So perhaps Ethier is such an acrobat that can ride the 2-Skate, which cannot really be rideable by ordinary cyclists. Answering the question whether the 2-Skatre is rideable or not by cyclists, was the objective of the present study.

Methodology: Equipped with a helmet and boot crampons, the rider sat on the 2-Skate. If feeling OK, he was pushed by someone else: (a) He only tried to stay up without forcing the handlebar, as he would do on a bicycle. (b) He was next asked to slalom through a line of four orange cones, each distanced 2 meters apart, to confirm his turning ability. (c) Then he was asked to do a constant slalom without the cones, left-right-left-right... towards a camera filming him. (d) He was finally asked to go straight, then do an 8 meter large right turn towards another camera, and keep on turning past it, so the camera could picture him in this large somewhat steady-state turn. Pictures, videos, personal information, and weather conditions were recorded.

Results: Twelve riders have tested the 2-Skate. A 79 year old only did the first part going straight. All others that were not acrobats but active cyclists, went riding it and slaloming as they would do on their bicycles. Constant slaloming tests clearly showed a phase lag between the rider torso lean angle to the vertical and the vehicle lean angle, as predicted by the TAH Theory and servomechanism theory. And vehicle lean angle being larger than torso lean angle was also clearly confirmed, also as predicted by the TAH Theory, further supporting it. For safety purposes, only Pierre Ethier demonstrated to them that removing the hands from the handlebar, simply let the 2-Skate keep on going and immediately fall, since nothing controlled the handlebar – or in servomechanism words: the feedback loop was removed.

Conclusions: Without wheels, fork angle, trail or motive power, the 2-Skate was easily rideable with the Torso-Arms-Handlebar or TAH mechanism present. Removing this mechanism definitely made the vehicle fall. This supports that the TAH Theory definitely explains part of what makes bicycles and motorcycles rideable and steerable. Thus this theory: (a) sheds light on how bicycles are steered, and it could be considered in any further single-track vehicle study, (b) clarifies that Countersteering is done automatically at low speeds, (c) supports and clarifies the way mountain bike steering is taught, (d) suggests a slight modification of the way motorcycle Countersteering is taught, with more emphasis on leaning towards where you want to go, (e) can be used to develop a different approach to 2-Wheeler simulations where torso lean angle would control front-wheel orientation, (f) and can be used to develop special steering means that could renew interest for development of motorcycles with seat belts and protective structure like the BMW-C1, and the closed-cabin electric motorcycles like the ultra-low drag and award winning Peraves e-Tracer.

References: