EUROPEAN COMMISSION
RESEARCH EXECUTIVE AGENCY

MOTORIST
7th FRAMEWORK PROGRAMME
Marie Curie Initial Training Network (ITN)
Grant Agreement 608092

MOTOrcycle Rider Integrated Safety

Deliverable No. D2.4
Work Package 2 Integrated Safety
~ PTW Rider Control ~

Applications of human performance measures and motor control theory to Motorcycle Safety Research

Deliverable no.	D2.4
Dissemination level	Confidential
Work Package	2
Author(s)	Marilee M. Nugent, PhD, ESR 2.3b
Co-author(s)	
Status (F: final, D: draft)	F
File Name	MOTORIST-Deliverable D2.4 MNugent.pages
Project Start & End Dates	February 1, 2014 - January 31, 2018

Table of contents

Glossary

ABS	Antilock braking system.
AccyPTW	Horizontal acceleration of the vehicle measured from sensor #16 placed on the vehicle inertial measurement unit (IMU).
AcczRL4	Acceleration of the approximately horizontal axis of sensor #2 at the right L4 level on the rider.
AD	Anterior deltoid muscle.
APAs	Anticipatory postural adjustments.
ARAS	Automatic rider assistive systems.
Behavior	Any innate or learned action that is goal directed and changes the relationship between the actor and the environment.
CNS	Central nervous system.
COM	Centre of mass.
CRT	Choice reaction time - time required to initiate the correct response among several choices after receiving on several possible sensory stimuli (e.g. different coloured lights indicate which target should be reached. CRT latency increases with the number of possible stimulus-response pairings.
DIEF	Department of industrial engineering, Florence (UNIFI).
ECU	Extensor carpi ulnaris muscle.
EMG	Electromyography.
ES	Erector spinae muscle(s).
ESR	Early stage researcher. Position title for MOTORIST research fellows.
Excitation	A neurological signal/command that causes an increase in muscle activity.
FCR	Flexor carpi radialis muscle.
Focal task	A specific motor behavior - for example, manipulating a control with the hand - as distinct from a postural adjustment that facilitates the task.
GA	Gastrocnemius muscle.
GS	No indicator, car goes straight (experimental condition).
IMU	Inertial measurement unit.
Inhibition	A neurological signal/command that causes a decrease in muscle activity.
IS	Turn indicator, car goes straight (experimental condition).
IT	Turn indicator, car turns (experimental condition).
L	Left side.
L4	Fourth lumbar vertebral level.
LLR	Long latency reflex - a reflex action that is slower than a simple stretch reflex and is thought to involve a transcortical circuit for a more complex action of integrated movement across multiple joints.
M GA	Gastrocnemius muscle (medial head).
MAEB	Motorcycle automatic emergency braking - a smart technology, still in the developmental stages, that executes automatic braking in the event of an immanent collision when the rider fails respond effectively.

MAIDS	In-Depth Investigation of Motorcycle Accidents - European database comprised of 921 accidents from 1999-2003 across 5 European countries.
Multistrada	A large model of motorcyle (1200 cc) produced by Ducati Motor Holding, S.P.A designed for touring on and off road. It is equipped with an ABS system.
MYMOSA	Motorcycle and moped safety - Marie Curie Actions Research Training Network project funded by the EU under the 6th Framework Programme (Grant Nr. 35965).
Novel rule	The next task, which is not known in advance but must be prepared de novo, requiring more time for response than a learned motor skill.
NT	No turn indicator, car turns (experimental condition).
PCA	Principal component analysis. A statistical method used on EMG data to determine the number of different muscle synergies activated to control a given movement.
Prime mover	The main muscle responsible for creating a specific joint action. Generally this is the muscle with the greatest mechanical advantage for performing the joint rotation, given its location, size and orientation with respect to the joint and desired action.
PTW, PTWs	Powered two-wheelers - motorcycles and scooters larger than a moped.
R	Right side.
R1, R2, R3	Response 1, 2 and 3 respectively. Epochs of automatic change in muscle activity in response to a mechanical perturbation (or for R2, R3, a visual stimulation with +30 ms). R2 and R3 have increasingly longer latencies than R1 (simple stretch reflex), due to the greater complexity of neural connections involved, which thus require more time for signal processing of sensory input to motor output.
S.P.A	Società per azioni - “public company”.
Segment	A defined part of the body between two moving joints, for example, the forearm, upper leg, head, thorax, pelvis, foot.
SEMG	Surface electromyography.
Sensory-motor Processes	The neurological activity underlying the organization and production of movement in response to sensory stimuli.
Spinal reflex	A neural circuit located within the spinal cord that produces an outgoing signal to generate an automatic motor action in response to an incoming sensory signal, with no intervention from the brain. Examples are the patellar tendon reflex (localized response to unexpected stretch of muscle/tendon) or the more complex withdrawal reflex (coordinating whole limb movement response to pain). Because the response is involuntary, the action is produced faster than could be done under voluntary control.
SRT	Simple reaction time - time to initiation of one pre-planned (i.e. voluntary) response to one specific stimulus.
T1, T10	First thoracic, tenth thoracic vertebral levels.
TA	Tibialis anterior muscle.
TR	Triggered response - a type of SRT that involves a stimulus-locked switch from one ongoing behavior to another, and can be as fast as the R2 or R3 responses. A relevant example could be switching from accelerating to braking at the sight of a traffic hazard.
UNIFI	Università degli studi Firenze.
VM	Vastus medialis muscle.
WP1	MOTORIST Work Package 1: Rider Training.
WP2	MOTORIST Work Package 2: Integrated Safety.

SEVENTH FRAMEWORK PROGRAMME

List of Figures

List of Tables

Executive summary

Existing models of rider control of powered-two wheelers (**PTWs**) are typically restricted to describing the mechanical input-output response of the coupled rider-vehicle system and do not elucidate how the human nervous system organizes reaction-time voluntary movement in the performance of emergency maneuvers on a PTW. This investigation is necessary for parsing out the **sensory-motor processes** involved in the coordinated control of this and other complicated skills associated with PTW riding. By better understanding the control mechanisms and timeframes underlying each aspect of the production of emergency maneuvers, we can more effectively create targeted training programs and assistive technologies that are functionally aligned with the capabilities and limitations of human sensory-motor response, with the aim to effectively increase PTW rider safety.

Outcomes from previous projects (such as **MYMOSA**, MOTORIST D1.1) have identified the most dangerous accident scenarios and their precipitating causes in terms of human factors, and have highlighted the need for various interventions such as improved rider training, vehicle warning systems for both riders and car drivers, and smart systems that intervene with emergency maneuver support in the event of rider failure to respond effectively or in time to avoid a collision.

In this novel research on rider-motorcycle integration, we enhance the current paradigm that uses instrumented vehicles to record rider control inputs and vehicle motion outcomes, by adding measurement of the rider's muscle activation patterns and body **segment** motions. With the aid of wireless wearable sensors that allow normal movement while riding freely, we are currently performing investigations never before undertaken, with the aim of more precisely elucidating the nature of rider control of PTWs. We have begun our investigation with emergency braking in response to an opposing vehicle turning unexpectedly across the rider's path. We have developed a protocol that recreates this traffic hazard, realistically reflecting the natural perception-action coupling that characterizes this and other real-world PTW-riding skills. We have established that this protocol can be conducted safely and efficiently. We have collected a large data set from full experiments using 19 volunteers and are currently analyzing the results.

In this report we not attempt to develop a new rider control model from scratch, but rather address gaps and limitations in current models, providing new data and directions in research questions and suggest analytic and interpretive methods relevant to the design of integrated safety technology such as motorcycle automatic emergency braking (**MAEB**).

Acknowledgements

Funding for the project MOTORIST (MOTOrcycle Rider Integrated SafeTy) was provided by the Marie Curie Innovative Training Network funded by the EU under the 7th Framework Programme (Grant project No. 608092). The experimental paradigm and protocol were developed in collaboration with **WP1** members Pedro Huertas-Leyva and Simon Rosalie. Thank you to Pedro Huertas-Leyva as co-investigator and to Cosimo Lucci, Dr. Giovanni Savino and Dr. Simon Rosalie for taking part in conducting the field experiments. The activity with the Ducati **Multistrada** was conducted in collaboration with Ducati Motor Holding S.P.A.