ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

# COMPUTATIONAL-RABI'S DRIVER TRAINING MODEL FOR PRIME DECISION-MAKING IN DRIVING

**[1]RABI MUSTAPHA, YUHANIS YUSOF[2], AZIZI AB AZIZ[3]**

[1]Ph.D., School of Computing, Universiti Utara Malaysia, Malaysia

[1]Ph.D., Senior Lecturer, Department of Computer Science, Kaduna Polytechnic, Nigeria

[2]Ph.D., Associate Professor, School of Computing, Universiti Utara Malaysia, Malaysia

[3]Ph.D., Senior Lecturer, School of Computing, Universiti Utara Malaysia, Malaysia

E-mail: [1]rabichubu@gmail.com, [2]yuhanis@uum.edu.my, [3]aziziaziz@uum.edu.my

**ABSTRACT**

Recent development of technology has led to the invention of driver assistance systems that support driving and help to prevent accidents. These systems employ Recognition-Primed Decision (RPD) model that explains how human make decisions based on prior experience. However, the RPD model does not include necessary training factors in making prime decision. Although, there exist an integrated RPD-SA model known as Integrated Decision-making Model (IDM) that includes training factors from Situation Awareness (SA) model, the training factors were not detailed. Hence, the model could not provide reasoning capability. Therefore, this study enhanced the IDM by proposing Computational-Rabi's Driver Training (C-RDT) model that includes improvement on RPD component of the IDM. The C-RDT includes 18 additional training factors obtained from cognitive theories that make a total of 24 training factors that facilitate driver's prime decision-making during emergencies. The designed model is realized by identifying factors for prime decision-making in driving domain, designing the conceptual model of the RDT model and formalizing it using differential equation. To demonstrate the designed model, simulation scenarios based on driver's training and awareness has been implemented. The simulation results are found to support related concepts found in literature. The results also provide insight into the robustness nature of the model. The computational model realized in this study practically can serve as a guideline for software developers on the development of driving assistance systems for prime decision-making process. Also, the computational model when combined with support components can serve as an intelligent artefact for driver's assistance system. Moreover, the C-RDT model offers reasoning ability that allows backtracking on why certain prime-decision has been made.

**Keywords:** *Computational Model, Integrated Decision-Making Model, Situation Awareness Model, Primed-Decision Making, Driving Assistance System.*

## 1. INTRODUCTION

The recent development of technology has led to the invention of driver assistance systems to help drivers in preventing the number of accidents on the road. For example, it provides warnings or interferes in the process of maneuvering the vehicle [1]. Gaining an insight into the development of drivers' assistance system, driver behavior models such as cognitive model of situation awareness [2–4] and naturalistic decision making model such as the Recognition-Primed Decision (RPD) model [5–7] are reviewed. The review of literature showed that there is existing Recognition-Primed Decision – Situation Awareness (RPD-SA) model called integrated decision-making model (IDM) for pilot decision process [8]. The model is divided into awareness and RPD training part. The awareness part of the IDM deals with the SA while the RPD part of the IDM deals with the prime decision-making process. However, in the RPD part of the IDM more training factors are needed which the current study attempts to address by enhancing the RPD part of the IDM using the training factors

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

relevant for prime decision-making in driving domain gained from SA model and other literatures. This is because SA model has a learning mechanism [9] to complement the underlying drawbacks. The importance of these missing training factors cannot be underemphasized as it is essential for any critical decision-making process.

Hence, driver training is essential to remove the barrier between knowledge and the skills required to drive safely and efficiently. The knowledge and skills that the driver needs to have must be known, for the training to be appropriate [10]. The objective of training for critical decision-making is to provide the learner with experiences and instruction on cues, patterns, mental models, and actions that efficiently establish a collection of well-learned concepts that enable the driver to perform mainly at the skill-based level of processing, while providing adequate knowledge-based foundation to perform well in new situations [11]. Training is also essential in recognizing situations, in communicating situation assessment, and in acquiring the experience to conduct mental simulation of options through the act of human cognitive unconscious decision making, or automaticity [5,12]. The driver training is modelled to predict the behaviour of the driver in making a prime decision.

Modelling is a concept used in understanding and predicting real phenomena or existing systems while the computational model is said to be a method of developing, comprehending and communicating theories [13]. The main goal of computational modelling is to check what is stated in theories about the behaviour of a system/model is obtainable in real life environment. In revealing the "real" behaviour of a system, the computational model can discover insights that non-computational model may not discover [13,14].

This paper presents an enhanced computational IDM called Computational-Rabi's Driver Training model that could be used for prime decision-making in the driving domain. The model integrates related dynamic factors that describe basic training factors required for prime decision-making by a driver. These factors are based on cognitive theory of Situation Awareness and naturalistic decision-making theory. Backtracking and providing reasoning ability on the undertaking decisions is the main advantage of the enhanced computational IDM. Thus, these are our previous work the Automaticity Recognition-Primed Decision training model (A*RPDT*) [15] and Situation Awareness (*SA*) model for decision making in driving [16,17] and the hybrid model for Prime Decision Making in driving [18]. The organization of the remaining part of this paper is as follows. The hybrid computational modeling is discussed in Section II. This is followed by a two-step verification process: the computational verification which is described in Section III and the mathematical verification explained in Section IV. In Section V, the simulation results are discussed in detail whereas the conclusions reached are presented in Section VI.

## 2. INTEGRATED DECISION-MAKING MODEL

The Integrated Decision-making Model in Noyes (2012) described the behavior of an aircraft pilot and was applied in supporting their decisions process. It also showed areas in the decision process where flaws can be made and may be detected. It suggested the use of decision support as an intervention points for prevention and correction of the errors. Aviation decision-making differs from decision-making in other fields. In aviation decision-making, the pilot starts with high SA which decreases over time as compared to others fields (such as fire fighters, military, driving e.t.c.). In this case, when the SA degrades, a potential for error occurs (i.e. when the pilot's mental representation (MR) is different from the actual situation), contrary to when a situation is wrongly assessed. When assessing a situation, time factor is also involved which may not be important when the situation is familiar. The IDM model by Noyes utilized three theories that are important for decision making processes in the development of their model. These theories are Endsley's theory of SA[19], the Naturalistic Decision Making theory [6] and the Rasmussen's theory of information processing [20].

The pilot situation awareness is very essential for effective decision-making. Endsley (2016) described SA as comprising of three components known as levels of SA. Level 1 SA is perception of cues; level 2 SA is comprehension of the cues and level 3 SA is the Projection of future developments. The Naturalistic Decision Making theory [5,6] is equally important for decision-making process in order to maintain MR and to identify which procedure is appropriate. Experience is important in matching the information and cues to a known situation and this is where Klein's model is most relevant. The Rasmussen's Skill-Rule-Knowledge theory [20] also serves as important theory in the pilot decision making process. The theory states that "different tasks require different levels of mental processing depending on the nature of the task".

Moreover, the use of MR [5,6,12] is important for successful decision-making. The IDM model shows the pilot's MR. The difference between the pilot's MR and the real situation plays a vital role in the decision process.. Analogous to SA, the RPD MR consists of three components: 1. Knowledge of what is happening (Perception of cues, level 1 SA), 2. Knowledge of rules governing situation (Comprehension of cues, level 2 SA), 3. Knowledge of possible consequences, or expectancies for the future (Projection of future developments level 3 SA). The levels in SA/ RPD models also relates to Rasmussen's theory of information processing which he called Skill-Rule-Knowledge theory [20].

The development of the IDM was as result of the reviewed of the decision-making theories mentioned. Based on Figure 1, there are three ways that the pilot may take in making a decision that are stated as follows:

- If there is not sufficient information, or the situation is complex, the individual may seek additional information to clarify their representation of the situation.
- If the pilot is satisfied with the representation, the pilot may form intentions to act.
- There will be effects and consequences of the pilot's actions, or failure to act.
- Points in the decision-making process where errors are likely to occur were identified in the model. The suggested intervention points are shown in Figure 1 as A, B, C and D.

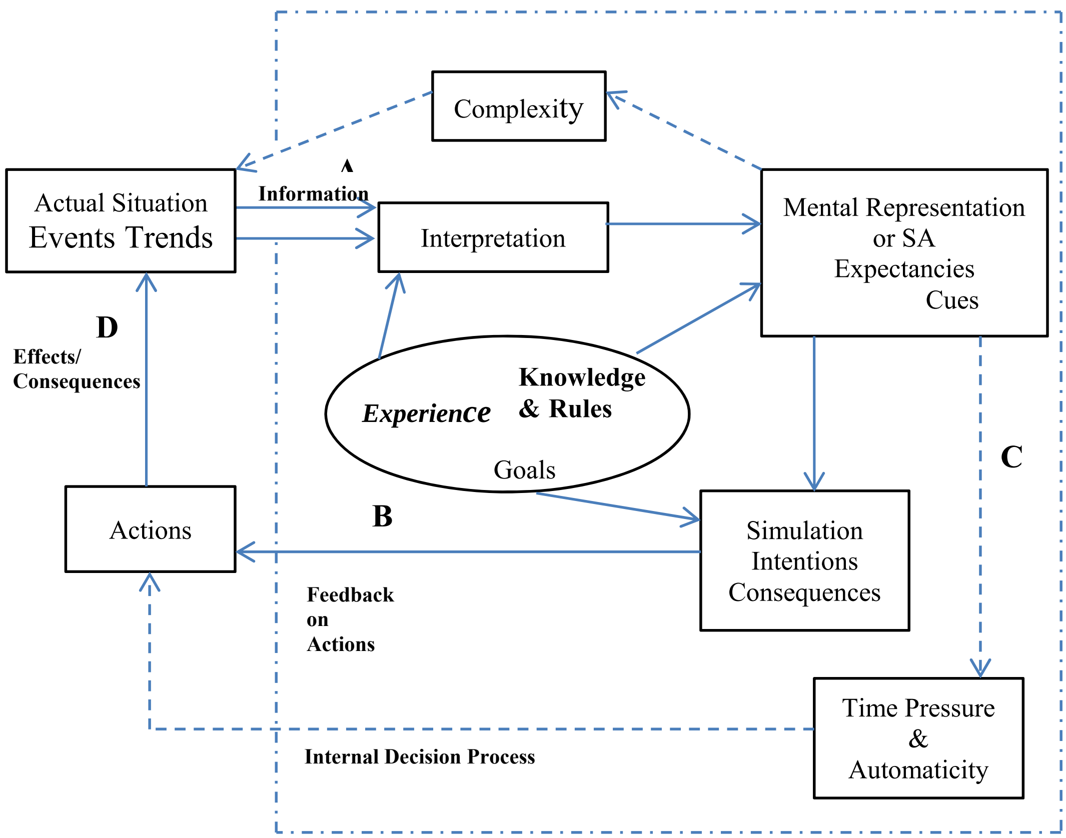


*Figure 1: Integrated Decision-making Model (IDM) Adapted from Noyes (2012)*

In the IDM model, when a situation of time pressure arises, a short cut can be taken that bypasses the process of forming intentions and considering consequences. In that case, when the situation is repetitive, the pilot might act or react automatically called automaticity and it is an important component for human decision-making and problem solving.

Based on Figure 1, the IDM model has twelve (12) factors for the pilot decision process including four

(4) external factors, seven (7) instantaneous factors and one (1) temporal factor as shown in Table 1.

*Table 1: IDM Model Factors*

| External Factors | Instantaneous Factors | Temporal Factors |
|---|---|---|
| 1. Actual Situation<br>▪ Events<br>▪ Trends | 1. Mental Representation (MR) or SA | 1. Action |
| 2. Knowledge/Rules | 2. Expectancies | |
| 3. Experience | | |
| 4. Goals | 3. Cues | |
| | 4. Complexity | |
| | 5. Intention | |
| | 6. Time Pressure | |
| | 7. Automaticity | |

The twelve (12) factors that were considered by the IDM model are presented in Figure 1 and Table 1. These factors are categorized into external, instantaneous and temporal factors. There are four (4) external factors, seven (7) instantaneous factors and only one (1) temporal factor.

The IDM model is further divided into two components namely, the SA and the RPD. The SA component of the model comprises of five (5) factors: Mental Representation (MR) or SA, Experience, Complexity, Time pressure and Automaticity. Whereas the RPD component is made up of the remaining seven (7) factors: Actual situation, Goals, Expectancies, Cues, Knowledge/Rules, Intention and Actions. Again, only six (6) of the factors are considered as the training factors in the IDM. These 6 factors are: experience, knowledge/rules, goals, complexity, intention and automaticity. Table 2 highlights the features of the existing IDM model.

*Table 2: Features of the existing Integrated Decision-making Model*

| Models | IDM of Pilot Decision Process |
|---|---|
| Features | ▪ Three paths of decisions; if not enough information or the situation is complicated, or when a situation is routine or if there is time pressure.<br>▪ It is a general model.<br>▪ It describes the way pilots make decisions and make errors.<br>▪ It shows the continuity of the decision-making process.<br>▪ Highlights that training is essential for the flight deck systems.<br>▪ six (6) training factors presented |
| Application Domain | ▪ Aviation |
| Weaknesses | ▪ The flight deck needs improvement using vital training factors.<br>▪ Conceptual model. |

## 3. RABI'S DRIVER TRAINING MODEL

The Rabi's Driver Training model (RDT) model is an enhancement of the IDM model. It has thirty-one (31) factors as against 12 for the IDM model. These thirty-one (31) factors identified were categorized into three different groups, namely external, instantaneous and temporal factors. The external factors serve as inputs and independent factors to the model, while the instantaneous and the temporal factors are the dependents factors. The two are time bounded factors but for the instantaneous factors the process is instant contrary to the temporal factors were the process involved much delay. The causal relationships among the categories of the factors are represented symbolically in form of nodes and flow arrows to form a conceptual model. The conceptual model is divided in terms of awareness and training. The conceptual model is further formalized in form of equations to obtain computational models [21]. Table 3 shows the comparison of IDM and the proposed RDT model factors.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

*Table 3: Comparison of Factors in IDM and the Proposed RDT Model*

| IDM Model (Noyes, 2012) | Proposed RDT Model |
|---|---|
| Actual Situation<br>▪ Events<br>▪ Trends | Environment |
| Mental Representation (MR) or SA | -Observation.<br>-Belief formation for current situation.<br>-Belief formation for future situation. |
| Goals | -Driver Goals |
| Expectancies | -Expectations |
| Action | -Decision |
| - | -Performance of Action |
| - | -Basic Practice.<br>-Practice. |
| - | -Basic Skills.<br>-Acquired Skills.<br>-Sensory Abilities.<br>-Potential Hazardous Information.<br>-Driver Abilities. |
| Experience | -Driver's Experience.<br>-Rehearsed Experience. |
| Complexity | -Exposure on Task Complexity. |
| Automaticity | -Experienced Automaticity.<br>-Attention.<br>-Priming.<br>-Habitual-directed Action.<br>-Goal-directed Action.<br>-Involuntary Automaticity.<br>-Voluntary Automaticity.<br>-Acquired Automaticity. |
| Cues | - |
| Simulation intention | -Intention. |
| | -Perception about Risk.<br>-Perception about Task.<br>-Perception about Hazard. |
| Time Pressure | - |
| Knowledge/Rules | -Driver's Knowledge. |

Table 3 shows the comparison between the IDM [8] and the proposed RDT model factors. The IDM offers less comprehensive training factors in it RPD component. It is a conceptual base model and hence need to be computational. Based on these drawbacks of the IDM for pilot decision making process, the present study proposed an enhanced IDM (RDT) model by improving on the RPD model component of the IDM. This is to be achieved by expanding some of the IDM training factors and adding some training factors obtained from SA model and other literatures. Although, two factors in the IDM, cues and time pressure will not be utilized in the proposed enhanced IDM. Based on that, eighteen (18) training factors such as Basic practice, Practice, Basic skills, Acquired skills, Sensory ability, Driver abilities, Rehearsed experience, Attention, Priming, Habitual-direction action, Goal-directed action, Involuntary automaticity, Voluntary automaticity, and Acquired automaticity. Others include experienced automaticity, Potential hazardous information, Perception about task and Perception about risk are realized in order to have a comprehensive conceptual model that has 24 relevant training factors to train the drivers to enhance their experiences to make prime decision particularly during demanding situations.

### 3.1 Notations and Explanations of Rabi's Driver Training model Factors

The external (exogenous) factors are independent factors that contribute to other factors, while instantaneous factors are dependent factors that are time-bounded with no delay. In contrast to the temporal factors that are time-bounded with delay.

There are nine (9) external factors identified in the RDT model. Two (2) of the factors are classified under the awareness component of the RDT, namely Environment and Expectations. While seven (7) of the factors were classified under the RPD training component of RDT , namely Basic practice, Basic skills, Sensory ability, Driver's goal, Potential hazardous information, Exposure on task complexity and Intention. They determined the outcome of the relationship between the external and instantaneous process. See Table 7 for the two classifications. The summary of the external factors of the RDT model is shown in Table 4

*Table 4: Summary of External factors of the Rabi's Driver Training model*

| Factors | Notation | Description | Related Theory/Models | References |
|---|---|---|---|---|
| Environment | *En* | The surrounding in which car and driver operate. | SA, TCI, UMD. | Endsley (1995, 2016); Fuller (2005) Hjälmdahl, Shinar, Carsten, & Peters (2011); Shinar & Oppenheim (2011). |
| Expectations | *Ep* | Knowledge of possible consequences or expectancies of the future. | SA, RPD, IDM | Endsley ( 1995, 2016); G. Klein (2008); Noyes (2012). |
| Basic Practice | *Bp* | The capacity to operate and control the vehicle | SA, TCI | Fuller (2005); [19,22]; [26]. |
| Basic Skills | *Bs* | The operational competence of driver | SA, TCI | [27] |
| Sensory Ability | *Sa* | The ability of driver to have cognitive, physical and visual functions to manipulate the vehicle | MM | [28]. |
| Driving Goal | *Dg* | Multiple driving aims that driver wants to achieve during the driving task. | SA, RPD,TCI, IDM | [29] |
| Potential Hazardous Information | *Hi* | Information acquired regarding potential threads that might need urgent respond in the traffic environment during driving. | MP | Borowsky, Shinar, & Oron-Gilad, (2010); Crundall et al.(2012); Horswill (2016); Huestegge and Bockler (2016). |
| Exposure on Task Complexity | *Tc* | The complexity driver exposes to at the course of the interaction with the vehicle and environment. | SA, TCI, RPD, IDM | Grill, Osswald, andTscheligi (2012). |
| Intention | *In* | Driver's mental state that translates his goals into reality | SA, IDM | Moskowitz (2013) |

Note: SA – Situation Awareness model, CMSA – Cognitive Model of Situation Awareness, RPD – Recognition-Primed Decision model, IDM – Integrated Decision-making Model for Pilot, TCI – Task-Capability Interface model, UMD - Unified Model of Driver Behavior.

There are sixteen (16) instantaneous factors identified in RDT model. Four (4) of the factors are classified under the awareness component of the RDT model, namely O*bservation, Belief formation, Belief activation,* and *Performance of action*. Twelve (12) of the factors are classified under the RPD training component of the RDT model, namely *Practice, Acquired skill, Rehearsed experience, Driver ability, Driver's experience, Perception about hazard, Perception about task, Attention, Priming, Habitual-directed action, Goal-directed action* and *Acquired automaticity* as shown in Table 5.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

*Table 5: Summary of Instantaneous Factors of the Rabi's Driver Training model*

| Factors | Notation | Description | Related Theory/Models | References |
|---|---|---|---|---|
| Observation | *On* | Ability to perceive elements in a driving environment. | SA,CMSA | Endsley (1995, 2016); Hoogendoorn, Lambalgen and Treur (2011). |
| Belief Formation | *Bf* | Ability to form certainty of the observation made. | CMSA | Hoogendoorn et al. (2011). |
| Belief Activation | *Ba* | Ability to translate the certainty of the observations into activation values of beliefs, which can be safe or risky. | CMSA | Hoogendoorn et al. (2011). |
| Performance of Action | *Pa* | Implementation of the decision taken by the driver. | SA, RPD and IDM | Endsley (1995, 2016). |
| Practice | *Pc* | Method of developing the drivers' skills and knowledge that relates to specific useful competencies of the driving task. | SA, TCI | Fuller (2005). |
| Acquired Skills | *As* | Accumulated exposure of the basic skills. | TCI | Fuller (2005). |
| Rehearsed Experience | *Re* | Experiences acquired due to continuous driving routine that might decay overtime. | SA | Gazzaniga, Heatherton, Halpern and Heine (2012) |
| Driver Ability | *Da* | Capability driver possesses to manipulate /operate car. | SA, TCI | Endsley (1995, 2016); Fuller (2005). |
| Driver's Experience | *De* | Driver's accumulation of the reoccurrence of knowledge or skill acquired that result from direct participation in the driving activity. | SA, TCI, RPD, UMD, IDM. | Shinar and Oppenheim, 2011); Oppenheim et al. (2012); Oppenheim, Enjalbert, Dahyot, and Pichon(2010) . |
| Perception about Hazard | *Hp* | Driver's ability to anticipate potentially dangerous situations on the road ahead. | MP | Horswill (2016). |
| Perception about Task | *Tp* | The way driver sees or experiences task in the potential traffic environment. | TCI | Fuller (2005). |
| Attention | *An* | The ability of driver to perceive multiple items in parallel accurately. | SA | Moskowitz (2013) |
| Priming | *Pg* | The stimulus that makes driver initiates response sequence in driving. | SA, IDM | Wheatley and Wegner (2001). |
| Habitual-directed action | *Hd* | Action initiated by driver as an act of unconsciousness while | SA, IDM | Moskowitz (2013); Wasserman and Wasserman (2016). |

| | | | | |
|---|---|---|---|---|
| | | driving | | |
| Goal-directed action | *Gd* | Action initiated by driver as an act of conscious willing while driving. | SA, IDM | Moskowitz (2013); Wasserman and Wasserman (2016). |
| Acquired Automaticity | *Aa* | Short-Term Automaticity. | SA, IDM | Panek, Bayer, Cin, and Campbell (2015) |

**Note:** SA – Situation Awareness model, RPD – Recognition-Primed Decision model, RPDT- Recognition-Primed Decision Training Model, IDM – Integrated Decision-making Model for Pilot, TCI – Task-Capability Interface model, MM - Multifactorial Model and MP - Model of Processes, UMD - Unified Model of driver behavior, WM- Working Memory, LTM- Long-Term Memory.

Six (6) temporal factors are identified in the RDT model based on the literature. Decision was classified in the awareness component of the RDT model. The other five factors such as Perception about risk, Driving knowledge, Involuntary automaticity, Voluntary automaticity and Experienced automaticity, are classified under the RPD training component of the model and the six factors determine the automaticity of the driver to perform effective decision-making. The summary of the temporal factors is shown in Tables 6.

*Table 6: Summary of Temporal Factors of Rabi's Driver Training model*

| **Factors** | **Notation** | **Description** | **Related Theory/Models** | **References** |
|---|---|---|---|---|
| Perception of Risk | *Rp* | Subjective experience of risk in potential traffic hazards. | TCI, MP | Rosenbloom, Shahar, Elharar, and Danino (2008). |
| Driving Knowledge | *Dk* | Knowledge of traffic rules and regulations of the road. | TCI, IDM | Stanton, Walker, Young, Kazi, and Salmon (2007) |
| Involuntary automaticity | *Iv* | Unconscious and automatic behaviors experienced by driver. | SA, IDM | Wheatley and Wegner (2001); Wasserman and Wasserman (2016). |
| Voluntary automaticity | *Vy* | Conscious and non-automatic behaviors experienced by driver | SA, IDM | Wheatley and Wegner (2001); Wasserman and Wasserman (2016). |
| Experienced Automaticity | *Ea* | Long-term automaticity that denotes accumulated exposure of the acquired automaticity of driver. | SA, IDM | Wheatley and Wegner (2001); Wasserman and Wasserman (2016). |
| Decision | *Dc* | The internal processes by which the driver selects a course of action or inaction from a set of alternatives | SA | Smith (2016). |

**Note:** SA – Situation Awareness model, RPD – Recognition-Primed Decision model, RPDT- Recognition-Primed Decision Training Model, IDM – Integrated Decision-making Model for Pilot, TCI – Task-Capability Interface model, MM - Multifactorial Model and MP - Model of Processes, UMD - Unified Model of driver behavior, WM- Working Memory, LTM- Long-Term Memory

*Table 7: Classification of Rabi's Driver Training model Factors and it Components*

| Classification of Factors | Awareness Component | RPD Component | Rabi's Driver Training model Factors |
|---|---|---|---|
| External | 1. Environment<br>2. Expectations | 1. Basic practice<br>2. Basic skills,<br>3. Sensory ability,<br>4. Driver's goal,<br>5. Potential hazardous information,<br>6.Exposure on task complexity and<br>7.Intention | 1. Environment<br>2. Expectations<br>3.Basic practice<br>4. Basic skills,<br>5. Sensory ability,<br>6. Driver's goal,<br>7.Potential hazardous information,<br>8.Exposure on task complexity and 9.Intention |
| Instantaneous | 1.Observation<br>2.Belief formation 3.Belief activation 4.Performance of action | 1. Practice,<br>2. Acquired skill,<br>3. Rehearsed experience,<br>4. Driver ability,<br>5. Driver's experience,<br>6. Perception about hazard,<br>7. Perception about task,<br>8. Attention,<br>9. Priming,<br>10. Habitual-directed action,<br>11. Goal-directed action and<br>12. Acquired automaticity | 1.Observation,<br>2.Belief formation, 3.Belief activation, 4.Performance of action<br>5. Practice,<br>6. Acquired skill,<br>7. Rehearsed experience,<br>8. Driver ability,<br>9. Driver's experience,<br>10. Perception about hazard,<br>11. Perception about task,<br>12. Attention,<br>13. Priming,<br>14. Habitual-directed action,<br>15. Goal-directed action and<br>16. Acquired automaticity |
| Temporal | 1. Decision | 1. Perception about risk<br>2. Driving knowledge<br>3. Involuntary automaticity,<br>4. Voluntary automaticity and<br>5. Experienced automaticity, | 1. Perception about risk,<br>2. Driving knowledge,<br>3. Involuntary automaticity,<br>4. Voluntary automaticity<br>5.Experienced automaticity, and<br>6. Decision. |
| **Total Factors** | **Seven (7)** | **Twenty four (24)** | **Thirty-one (31)** |

Table 7 shows the summary of the classifications of RDT model (awareness and RPD training components) and its factors (external, instantaneous and temporal factors).

### 3.2 Enhancing the Integrated Decision-making Model

In enhancing the IDM, training factors that are relevant for prime decision-making are identified from the SA model and other related literatures. The model is divided into two components; the situation awareness component and the Recognition-Prime Decision training component. The enhancement is to be done on the RPD training component of the IDM using those training factors identified. The original IDM had only six (6) training factors. In the enhanced IDM (RDT model), the RPD component of the model had twenty-four (24) training factors represented symbolically using nodes and flow arrows as shown in Figure 2. The nodes represented the states and the flow arrow denoted the causal relationship between the states. The nodes and flow arrows formed the conceptual model. This conceptual model explicitly indicates interactions between factors and relationship involved based on cognitive theories e.g., Endsley's theory of SA, Naturalistic Decision making.

The causal relationships produced an enhanced conceptual IDM called Rabi's Driver Training (RDT) model. The conceptual model is subdivided into generic and specific models for driving as shown in Figure 2 and 3. In the generic model, the factors as constructs are expanded in order to have a comprehensive model with training factors relevant for prime decision-making particularly during demanding situations.

The interactions that occur between the interrelated factors of the RDT model are presented

in Figure 2 and 3. In these figures, it can be seen that the model consists of several interrelated nodes that shows several external, instantaneous and temporal factors that interrelated with each other.
After the structural relationships of the model have been esterblished, the model is to be formalized. The formalization of the model is similar to these studies (Mustapha et al.,2017b; Aziz, Ahmad, Yusof, Kabir, & Azmi, 2016; Aziz, Klein, & Treur, 2009; Treur, 2016a, 2016b, 2016c). In the formalization, the relationships connecting all the nodes using flow arrows to show the relationship between the factors involved are shown. However, the relationship among the interrelated nodes aids in the reasoning ability of the model in the simulation environment using mat lab. Each factor has certain weight assigned to it contributing toward enhancing the automaticity of the driver to make decision particularly during demanding situation (such as *panic stop* and *sudden swerve* to another direction).

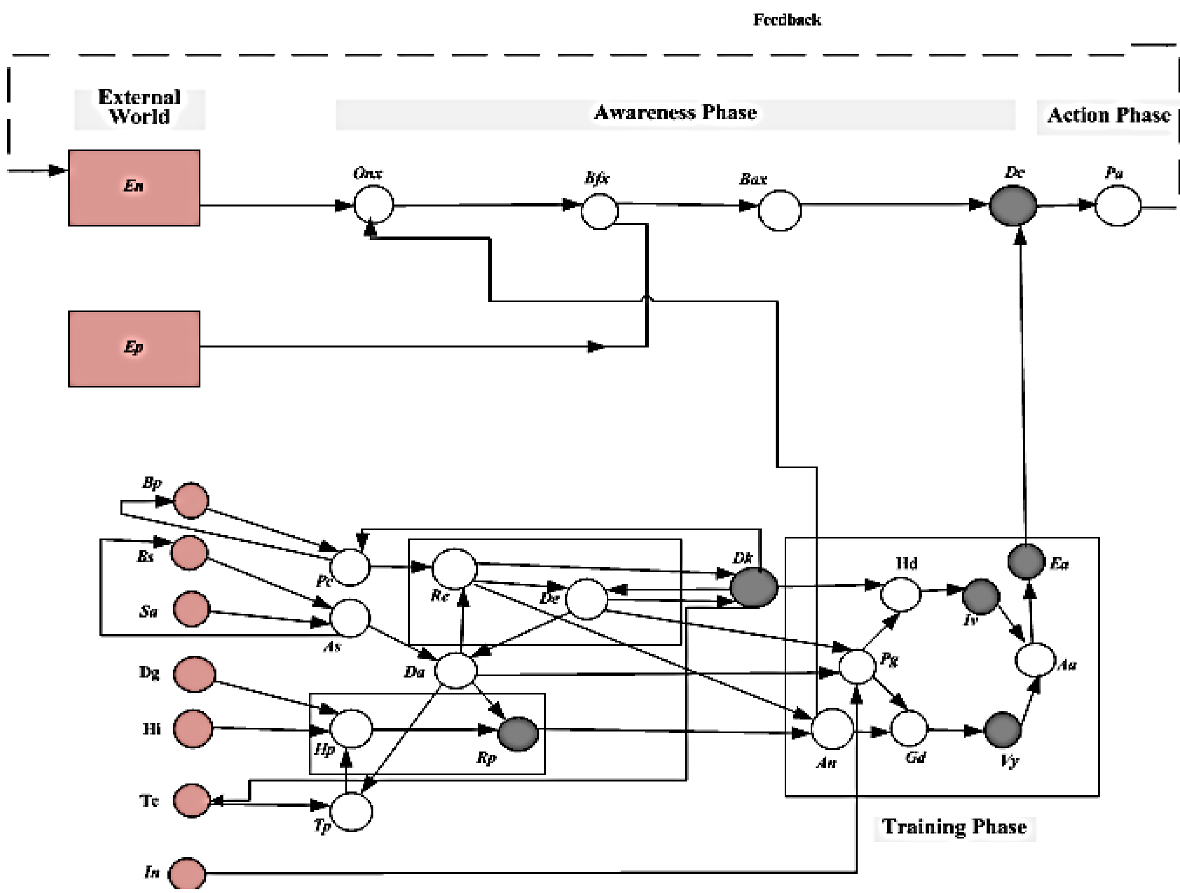


*Figure 2: Generic RDT model for Prime Decision-Making*

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

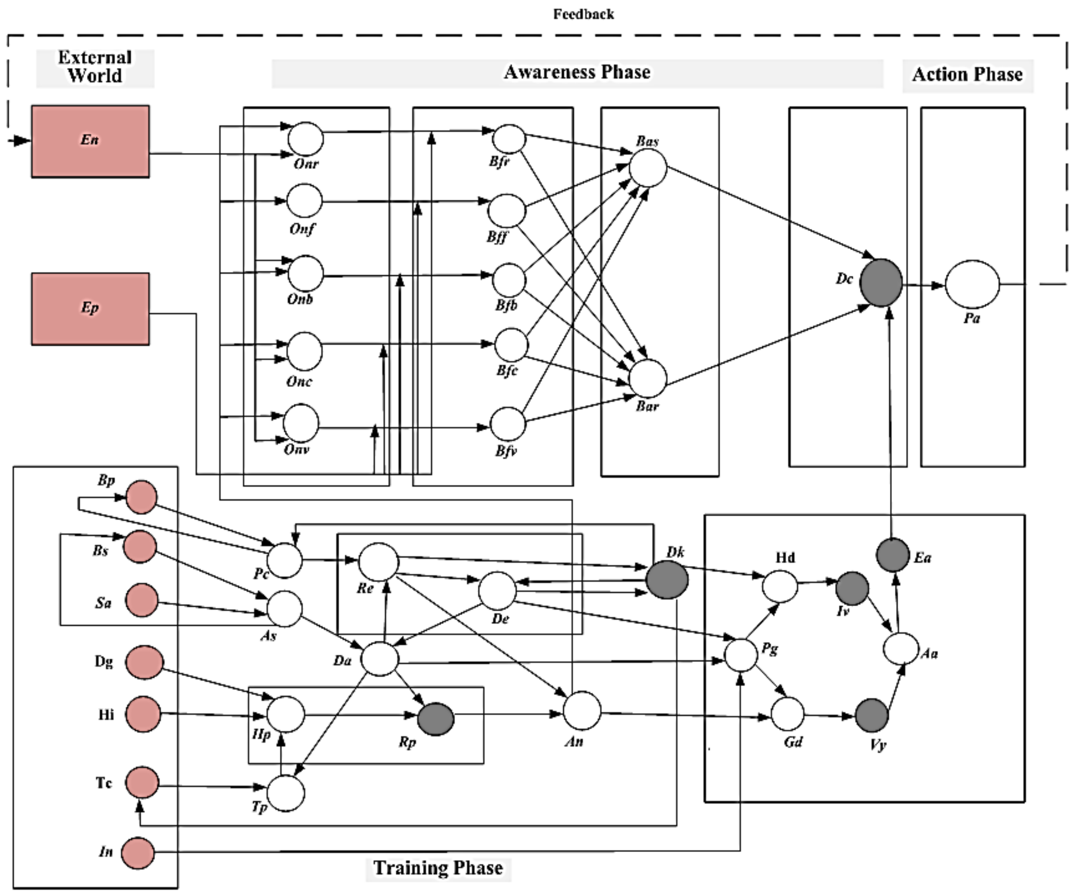


*Figure 3: RDT model for Prime Decision-Making in Driving*

## 4. FORMALIZATION OF THE RABI'S DRIVER TRAINING MODEL

This is a method used in converting our conceptual models into equations format by using the relationships of the factors based on theories. Thus, we have two types of relationships binding the connectivity of our models, the Instantaneous and the temporal.

### 4.1 Instantaneous Relationships

Basic practice (*Bp*) of the driver increased with practice (*Pc*). That is practice is influenced by basic practice (*Bp*) and driving knowledge (*Dk*).

$$Bp(t)=\beta_{bp}.Bp_{basic}(t)+(1-\beta_{bp}).Pc(t) \quad (1)$$

$$Pc(t) = \omega_{pc} . Bp(t)+(1- \omega_{pc}).Dk(t) \quad (2)$$

Rehearsed Experience (*Re*) of the driver is influenced by driver's practice (*Pc*) and ability (*Da*) by saying "with continuous practice any knowledge or skill is retained in short-term memory and later transfer to long-term memory otherwise it will decay". Next, the driver's experience (*De*) is influenced by rehearsed experience (*Re*) and driving knowledge (*Dk*) of the driver. The concept of acquired skills (*As*) is computed by combining driver's basic skills, and the driver's sensory ability (*Sa*).

$$Re(t) = \gamma_{re}.Pc(t)+(1-\gamma_{re}).Da(t) \quad (3)$$

$$De(t) = \lambda_{de}.Re(t) + (1- \lambda_{de}).Dk(t) \quad (4)$$

$$As(t) = \beta_{as} .[w_{as1}.Bs(t)+ w_{as2}.Sa(t)] +(1-\beta_{as}) \quad (5)$$

In the case of driver's ability (*Da*), this concept is influenced by the skills acquired and experiences of the driver (*De*) during the training session. The combination of driver's experience, ability and intention (*In*) generates priming levels. Perception about hazard (*Hp*) is determined by combining

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

concepts in driving ability (*Da*), perception about task (*Tp*) and potential hazardous information (*Hi*).

$$Da(t) = w_{da1}.De(t)+w_{da2}.As(t) \quad (6)$$

$$Pg(t) = [\xi_{pg}.Da(t)+(1- \xi pg ).De(t)].In(t) \quad (7)$$

$$Hp(t) = [w_{hp1}.Dg(t)+ w_{hp2}.Tp(t)].Hi(t) \quad (8)$$

Attention (An) is generated combining a proportional ratio of rehearsed experience (Re) and perception about the risk (Rp). Next, the proportional contribution between exposure on task complexity (Tc) and driving ability (Da) provides a computational concept of perception about task

$$An(t) = [\xi_{an}.Rp(t) +(1-\xi_{an}).Re(t)] \quad (9)$$

$$Tp(t)=[\eta_{tp}.Da(t)+(1-\eta_{tp}).Tc(t)] \quad (10)$$

Another important concept is the exposure on task complexity (*Tc*). This concept is positively correlated with the knowledge of the driver. Habitual-directed action (*Hd*) is influenced by driving knowledge (*Dk*) of the driver and priming (*Pg*). Using the same computational concept as in habitual directed action, priming (*Pg*) and attention (An) generates goal-directed action (*Gd*). Similarly, it also the case of acquired automaticity (*Aa*) as it is influenced by weight contribution of involuntary (Iv) and voluntary (*Vy*).

$$Tc(t)=\beta_{tc}.Tc_{basic}(t)+(1-\beta_{tc}).Dk(t) \quad (11)$$

$$Hd(t) =w_{hd1}.Pg(t)+ w_{hd2}.Dk(t) \quad (12)$$

$$Gd(t)=w_{gd1}.An(t)+w_{gd2}.Pg(t) \quad (13)$$

$$Aa(t)=w_{aa1}.Iv(t)+w_{aa2}.Vy(t) \quad (14)$$

Note that: Equations (1) to (14) are derived based on the relationship that shows the interrelated connectivity of the nodes in the conceptual model in Figure 2. $\beta_{bp}$, $\beta_{as}$, $\omega_{pc}$, $\gamma_{re}$, $\xi_{pg}$, $\xi_{an}$, $\eta_{tp}$, $\beta_{tc}$ are known as proportional parameters while $\lambda_{de}$ is a decay function. Moreover, $w_{as1}$, $w_{as2}$, $w_{da1}$, $w_{da2}$, $w_{hp1}$, $w_{hp2}$, $w_{hd1}$, $w_{hd2}$, $w_{gd1}$, $w_{gd2}$, $w_{aa1}$ and $w_{aa2}$ are weight parameters with $\sum w =1$. While (1- $\beta_{bp}$), (1- $\beta_{as}$), (1- $\omega_{Pc}$), (1-$\gamma_{re}$), (1- $\lambda_{de}$), (1- $\xi_{pg}$), (1-$\xi_{an}$), (1- $\eta_{tp}$) and (1- $\beta_{tc}$) are regulating functions in the equation in the equations.

### 4.2 Temporal Relationship

Driving knowledge (*Dk*) of the driver primarily contributed to the accumulation of rehearsed experience (*Re*) and driver's experience (*De*). Perception of the driver about risk (*Rp*) is influenced by perception of the driver about the hazard (*Hp*) and driver's ability to handle vehicle (*Da*), while the involuntary decision (*Iv*) is contributed through habitual-directed action (*Hd*). The positive change in goal-directed action (*Gd*) improves voluntary (*Vy*) level. Experienced automaticity is influenced by acquired the automaticity.

$$Dk(t+\Delta t) = Dk(t) + \gamma_{dk}.\Big[\Big(Pos\Big(\big(\omega_{dk1}.Re(t)+\omega_{dk2}.De(t)\big)-Dk(t)\Big).\big(1-Dk(t)\big)\Big) - Pos\big(-\big(\omega_{dk1}.Re(t)+\omega_{dk2}.De(t)\big)-\lambda_{dk}\big).Dk(t)\Big].\Delta t \quad (15)$$

$$Rp(t+\Delta t) = Rp(t) + \gamma_{rp}.\Big[\Big(Pos\Big(\big(\omega_{rp1}.Hp(t)+\omega_{rp2}.Da(t)\big)-Rp(t)\Big).\big(1-Rp(t)\big)\Big) - Pos\Big(-\big(\omega_{rp1}.Hp(t)+\omega_{rp2}.Da(t)\big)-Rp(t)\big)-\lambda_{rp}\Big).Rp(t)\Big].\Delta t \quad (16)$$

$$Iv(t+\Delta t) = Iv(t) + \beta_{iv}.\Big[\Big(Pos\Big(\big(Hp(t)-Iv(t)\big)\Big).\big(1-Iv(t)\big)\Big) - Pos\Big(-\big(Hd(t)-Iv(t)\big)\Big).Iv(t)\Big].\Delta t \quad (17)$$

$$Vy(t+\Delta t) = Vy(t) + \beta_{vy}.\Big[\Big(Pos\big((Gd(t) - Vy(t))\big).(1 - Vy(t))\Big) - Pos\big(-(Gd(t) - Vy(t))\big).Vy(t)\Big].\Delta t \quad (18)$$

$$Ea(t+\Delta t) = Ea(t) + \beta_{ea}.\Big[\Big(Pos\big((Aa(t) - Ea(t))\big).(1 - Ea(t))\Big) - Pos\big(-(Aa(t) - Ea(t))\big).Ea(t)\Big].\Delta t \quad (19)$$

$$Dc(t+\Delta t) = Dc(t) + \gamma_{dc}.\big((\text{Bas}(t) - \text{Bar}(t)) - Dc(t)\big).(1 - Dc(t)).\Delta t \quad (20)$$

Note: that the equations (15) – (20) are derived based on the concepts of the differential equation. The change process in these equations is measured in a time interval between $t$ and $t+\Delta t$. Moreover, the rate of change for all temporal specifications is determined by flexibility rates $\gamma_{dk}$, $\gamma_{rp}$, $\beta_{iv}$, $\beta_{vy}$ and $\beta_{ea}$ which are change rate parameters. The derivation of all the equations in this paper follows the same concepts used in our papers [16,18] and in [49]. A simulator was developed using all defined formulas for experiment purposes; precisely to explore interesting patterns and traces that explains the behaviour of driver as an agent in performing decision.

## 5. SIMULATION RESULT

This section demonstrates the mechanism of the proposed RDT Model whereby three scenarios were simulated using fictional driver's conditions as shown in Table 8. The simulations conditions are based on the input values of the seven input factors of the training model (basic practice, basic skills, sensory ability, driver's goal, potential hazardous information, exposure on task complexity and intention) where 0 means poor and 1 means good for those inputs. We also have the input values based on of the five input factors conditions (road, traffic, obstacles, car condition and visibility) of the awareness model where 1 means good and 0 means bad for all the awareness input factor conditions except obstacle. These relationships are simulated using Mat lab and in the simulation, each of the factors is assigned value of either zero (0) or one (1) where zero (0) means low, and one (1) means high for those external factors that serves as the inputs in the simulation experiments. In this simulation, the following settings were used: ($0 \le t \le 500$) with $t_{max} = 500$ (to represent a set of training activities of the driver up to eight months). Each time step (i.e., range) denotes the training hours where one (1) time step represents 5 hours of training. The parameters are as follows; $\Delta t = 0.3$, $\lambda = 0.01$. All proportional and flexibility rates equal to 0.6. These settings were obtained from a number of experiments to determine the best convergence based on the existing studies [49,51–55] which suggested the use of 0.1 to 0.3 as low values, 0.4 to 0.6 as average values, and 0.7 to 1.0 as high values.

The scenarios and conditions for the enhanced model (C-RDT model) are presented in Table 8. Each scenario is presented with training and awareness conditions and are named long-term, medium-term and short-term training, respectively. Based on the conditions for each scenario, graphs were generated as the simulation results for three scenarios as shown in Figure 4, Figure 5 and Figure 6 respectively.

*Table 8: C-RDT Model Training Conditions*

| Scenarios | Training conditions | | | Awareness conditions | | | Description |
|---|---|---|---|---|---|---|---|
| One | 1110111 | 1111011 | 1111111 | 11011 | | | The driver receives more training compare to awareness. |
| Two | 1110011 | 1110110 | | 01011 | 10011 | | The driver receives equal proportion of training and awareness. |
| Three | 1110101 | | | 00011 | 11111 | 11001 | The driver receives less training compared to awareness. |

Note: For training model, 7 input factors (basic practice, basic skills, sensory ability, driver's goal, potential hazardous information, exposure on task complexity and intention) are used. Each of the factors is assigned value either 0 or 1, where 0 means low/poor training and 1 means high/good training. For the awareness model, 5 input factors (Road, Traffic, Obstacles, Car condition and Visibility) are used where 1or 0 represent good or bad/poor, respectively with the exception of obstacle in which the reverse is the case.

### 5.1 Scenario One: The Long-Term Training Exposure

In Scenario 1, Figure (4a) depicts that the driver's level of perception about risk increased with increment in driver's knowledge. However, the driver's level of perception about risk decreased to a certain level due to the effect of driver's low-level perception about potential hazardous information. The level eventually increased again due to good driving condition and skill of the driver. Figure (4b) shows that the driver's experienced automaticity level increased due to exposure to long-term training, which led to a high confidence level to make decision. Figure (4b) also supports the claim that the computational-RDT model can reason in the sense that in the simulation environment when the driver is exposed to long-term training, it can easily be identified by the high level contribution of the factors that influences the experienced automaticity of the driver and that led to high confidence by the driver to make decision. Figure (4c) shows that long-term training led to high performance of action by the driver subject to the driver's confidence level to make decision. If it is high the performance of action of the driver will be high [indicated by yes (1)] and if it is low the performance of action of the driver will be low, indicated by no (0).

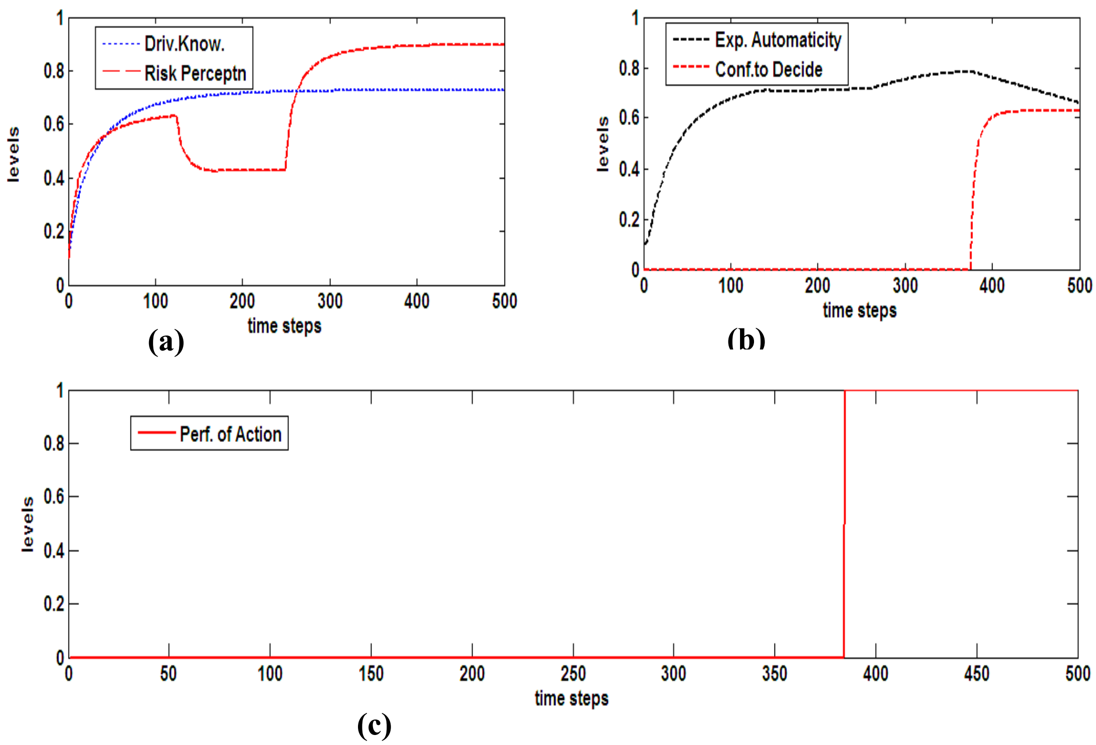


*Figure 4: Simulation Conditions Results (for Scenario 1)*

### 5.2 Scenario Two: The Medium-Term Training Exposure

In Scenario 2, Figure (5a) visualizes that the driver's level of perception about risk increased with proportional increase in driver's knowledge but the driver's level of perception about risk decreased a bit to a certain level due to the effect of driver's low level of potential hazardous information in the traffic environment. The driver's level of perception about risk eventually increased and became stable due to the skillfulness of the driver and other good driving conditions. Result in Figure (4b) showed that experience automaticity of the driver increased and later decreased due to equal proportion of training and awareness given to the driver. Hence, this led to low confidence level of the driver to make decision as it has been visualized in Figure (5b). Same claim in Figure (5b) to show that the enhanced computational model can reason. Due to equal proportion of training and awareness given to the driver in the simulation, the experienced automaticity level of the driver became low compare to Figure (4b) which led to low confidence to make decision. Figure (5c) provides a visual representation of driver's low performance due to equal proportion of training and awareness given to the driver, indicated by no (0).

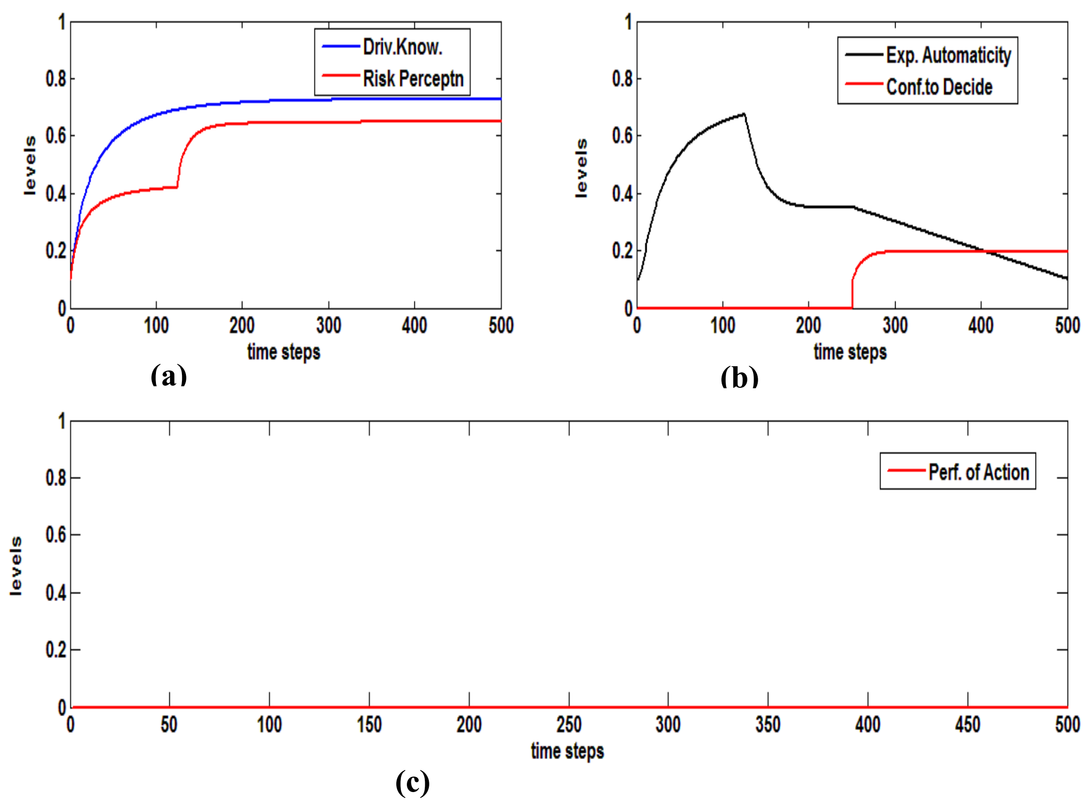


*Figure 5: Simulation Conditions Results (for Scenario 2)*

**5.3 Scenario Three: The Short-Term Training Exposure**

In Scenario 3, Figure (6a) indicates that the driver's level of perception about risk increased with proportional increase in driver's knowledge to a certain level and eventually decreased drastically due to a very short period of training. Result in Figure (6b) indicates that driver's experienced automaticity level decreased with a very short period of training and high awareness which led to a very low confidence level to make a decision. The same Figure (6b) support the assumption that the enhanced computational model can reason. As a result of very short-term of training and high awareness in the simulation, experienced automaticity level of the driver decreased which led to very low confidence to decide. Result in Figure (6c) indicates that very short-term of training led to lower performance of action by the driver as indicated by no (0).

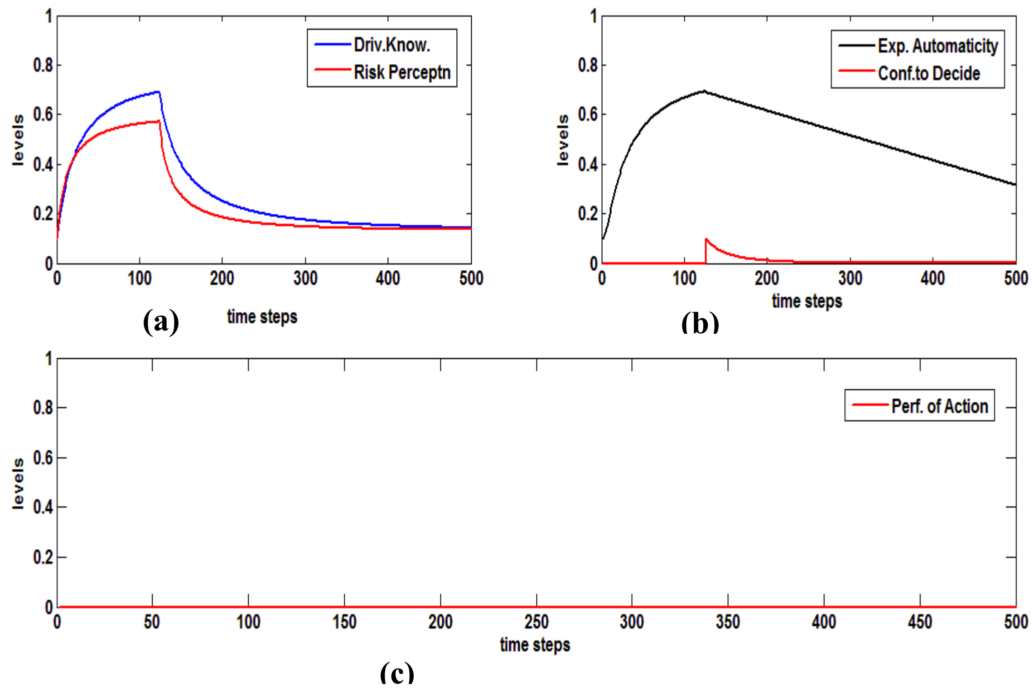


*Figure 6: Simulation Conditions Results (for Scenario 3)*

### 5.4 Result Discussion:

This section discusses the differences of the proposed Computational-Rabi's Driver Training model with the IDM for pilot decision making process by [8]. Based on the simulation results presented in this paper, three scenarios that were presented are; long-term, medium-term and short-term training. Each scenario was presented with training and awareness conditions. The three results depicts the impacts of training on the driver's knowledge, their perception about risk, experienced automaticity, confidence level to make decision which results to the driver's performance of action. It shows that when the driver is exposed to long-term training, the result indicates that his knowledge will be high; perception about risk will be high; his experienced automaticity will be high that led to high confidence level to make decision. These automatically increased the driver's performance of action. This applies to the other two scenarios. This means that the more the training acquired by the driver the higher the improvement on the decision making of the driver in demanding situations (such as *panic stop* and *sudden swerve* to another direction) and vice versa. This shows that the training factors in the in the proposed model are important in improving driver's prime decision making.

## 6. CONCLUSION

This paper presented Computational-Rabi's Driver Training model that is an enhancement of IDM. This is done by expanding the IDM training factors and adding some training factors obtained from SA model and other literature in order to have a comprehensive conceptual model. The model contains 24 training factors which will help drivers to enhance their experience in making prime decision particularly during demanding situations. The proposed model has formalized and simulated based on real scenarios to provide insight into the robustness nature of a model. It has shown that the simulation results are related to existing concepts that can be found in literatures. It has also proved that, for a given scenario, the external factors of the enhanced model effect the automaticity of the driver in making prime decision. This has later influenced the driver's action. It has also shown that the model has the capability to reason on why certain prime-decision is made (that is in the simulation environment if the automaticity of the driver to make decision is high it should be traced out based on the contributing factors and vice versa). To further evaluate C-RBT model, the study will later need to undergo validation process that includes mathematical analysis and human experiment. This will help to ensure the applicability of the model in real life domain.

## REFERENCES

[1] T. Vaa, T. Assum, R. Elvik, Driver Support Systems and road safety outcomes: Potential effects on fatal accidents, in: Pap. Present. 20th World Congr. ITS, 2013.

[2] M.R. Endsley, Theoretical underpinnings of Situation Awareness: A critical review, in: E. M. R., G. D. J. (Eds.), Situat. Aware. Anal. Meas., Lawrence Erlbaum Associates, NJ, 2000: pp. 3–32. doi:10.1016/j.jom.2007.01.015.

[3] M. Jeon, B.N. Walker, T.M. Gable, The effects of social interactions with in-vehicle agents on a driver's anger level, driving performance, situation awareness, and perceived workload, Appl. Ergon. 50 (2015) 185–199. doi:10.1016/J.APERGO.2015.03.015.

[4] N.A. Stanton, P.M. Salmon, G.H. Walker, E. Salas, P.A. Hancock, State-of-science: Situation Awareness in individuals, teams and systems, Ergonomics. 60 (2017) 449–466. doi:10.1080/00140139.2017.1278796.

[5] G. Klein, Naturalistic Decision Making, Hum. Factors Ergon. Soc. 50 (2008) 456–460. doi:10.1518/001872008X288385.

[6] G. Klein, A naturalistic decision making perspective on studying intuitive decision making, J. Appl. Res. Mem. Cogn. 4 (2015) 164–168. doi:10.1016/j.jarmac.2015.07.001.

[7] G. Klein, R. Calderwood, A. Clinton-Cirocco, Rapid Decision Making on the fire ground: The original study plus a postscript, J. Cogn. Eng. Decis. Mak. 4 (2010) 186–209. doi:10.1518/155534310X12844000801203.

[8] J. Noyes, Automation and decision making, in: J. Noyes, M. Cook, Y. Masakowski (Eds.), Decis. Mak. Complex Environ., Ashgate Publishing, Ltd., UK, 2012: pp. 113–122.

[9] M.R. Endsley, Toward a Theory of Situation Awareness in Dynamic Systems, in: Eduardo Salas (Ed.), Situat. Aware., Routledge, 2017: p. 34. doi:10.4324/9781315087924-3.

[10] S. Vegvesen, Driver training in Norway: Foundations for the revisions of the regulations and curricula, NPRA Directorate of Public Roads, Norway, 2014.

[11] F.L. Greitzer, R. Podmore, M. Robinson, P. Ey, Naturalistic Decision Making for power system operators, Int. J. Hum. Comput. Interact. 26 (2010) 278–291. doi:10.1080/10447310903499070.

[12] G. Klein, A Recognition-Primed decision (RPD) model of Rapid Decision making. Decision making in action: Models & Methods, in: G. Klein, J. Orasanu, R. Calderwood, C.E. Zsambok (Eds.), Decis. Mak. Action Model. Methods, Norwood, NJ: Ablex Publishing Corporation, Norwood, NJ, 1993: pp. 138–147. doi:10.1002/acp.2350080609.

[13] R. Ma, D.B. Kaber, Situation awareness and driving performance in a simulated navigation task, Ergonomics. 50 (2007) 1351–1364. doi:10.1080/00140130701318913.

[14] S. Farrell, S. Lewandowsky, Computational Models as aids to better reasoning in psychology, Curr. Dir. Psychol. Sci. 19 (2010) 329–335. doi:10.1177/0963721410386677.

[15] R. Mustapha, Y. Yusof, A.A. Aziz, A Computational Agent Model of Automaticity for Driver's Training, in: Int. Res. Innov. Summit, IOP Publishing, 2017: pp. 1–7. doi:10.1088/1757-899X/226/1/012083.

[16] R. Mustapha, A.A. Aziz, Y. Yusof, Computational Model of Situation Awareness for Action Performed in Driving, Malaysian J. Hum. Factors Ergon. 1 (2016) 1–8.

[17] R. Mustapha, Y. Yusof, A.A. Aziz, Computational Model of Situation Awareness for Decision Making in Driving, Adv. Sci. Lett. 24 (2018) 1244–1248. doi:10.1166/asl.2018.10725.

[18] R. Mustapha, Y. Yusof, A.A. Aziz, A Hybrid Model for Prime Decision Making in Driving, Ournal Telecommun. Electron. Comput. Eng. 9 (2017) 95–99. https://www.researchgate.net/profile/Rabi_Mustapha/publication/321105784_A_Hybrid_Model_for_Prime_Decision_Making_in_

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Driving/links/5a0d91dca6fdcc39e9c131c3/A-Hybrid-Model-for-Prime-Decision-Making-in-Driving.pdf (accessed April 16, 2018).

[19] M.R. Endsley, Designing for Situation Awareness: An approach to User-Centeres Design, M. R., End, CRC Press and Taylor & Francis Group, 2016.

[20] J. Rasmussen, Deciding and doing: decision making in natural context, in: Decis. Mak. Action Model. MMethods, Ablex Publishing, 1993.

[21] A.A. Aziz, F. Ahmad, N. Yusof, F.K. Ahmad, S.A.M. Yusof, Formal analysis of temporal dynamics in anxiety states and traits for virtual patients, in: 2016: p. 020001. doi:10.1063/1.4960841.

[22] M.R. Endsley, Toward a theory of Situation Awareness in dynamic systems, Hum. Factors J. Hum. Factors Ergon. Soc. 37 (1995) 32–64. doi:10.1518/001872095779049543.

[23] R. Fuller, Towards a general theory of driver behaviour, Accid. Anal. Prev. 37 (2005) 461–472. doi:10.1016/j.aap.2004.11.003.

[24] M. Hjälmdahl, D. Shinar, O. Carsten, B. Peters, The ITERATE Project—Overview, theoretical framework and validation, Springer, 2011. doi:10.1007/978-88-470-1821-1_10.

[25] D. Shinar, I. Oppenheim, Review of models of driver behaviour and development of a Unified Driver Behaviour Model for driving in safety critical situations, in: Hum. Model. Assist. Transp., Springer Milan, Milano, 2011: pp. 215–223. doi:10.1007/978-88-470-1821-1_23.

[26] C. Freydier, C. Berthelon, M. Bastien-Toniazzo, Does early training improve driving skills of young novice French drivers?, Accid. Anal. Prev. 96 (2016) 228–236. doi:10.1016/j.aap.2016.07.026.

[27] S. Imhoff, M. Lavalliere, M. Germain-Robitaille, N. Teasdale, P. Fait, Training driving ability in a traumatic brain-injured individual using a driving simulator: A case report, Int. Med. Case Rep. J. 10 (2017) 41–45. doi:10.2147/IMCRJ.S120918.

[28] K.J. Anstey, J. Wood, S. Lord, J.G. Walker, Cognitive, sensory and physical factors enabling driving safety in older adults, Clin. Psychol. Rev. 25 (2005) 45–65. doi:10.1016/j.cpr.2004.07.008.

[29] E. Dogan, L. Steg, P. Delhomme, The influence of multiple goals on driving behavior: The case of safety, time saving, and fuel saving, Accid. Anal. Prev. 43 (2011) 1635–1643. doi:10.1016/j.aap.2011.03.002.

[30] A. Borowsky, D. Shinar, T. Oron-Gilad, Age, skill, and hazard perception in driving, Accid. Anal. Prev. 42 (2010) 1240–1249. doi:10.1016/j.aap.2010.02.001.

[31] D. Crundall, P. Chapman, S. Trawley, L. Collins, E. Van Loon, B. Andrews, G. Underwood, Some hazards are more attractive than others : Drivers of varying experience respond differently to different types of hazard, Accid. Anal. Prev. 45 (2012) 600–609. doi:10.1016/j.aap.2011.09.049.

[32] M.S. Horswill, Hazard perception in driving, Curr. Dir. Psychol. Sci. 25 (2016) 425–430. doi:10.1177/0963721416663186.

[33] L. Huestegge, A. Bockler, Out of the corner of the driver ’ s eye : Peripheral processing of hazards in static traffic scenes, 16 (2016) :11, 1-15. doi:10.1167/16.2.11.doi.

[34] T. Grill, S. Osswald, M. Tscheligi, Task complexity and user model attributes, Comput. Help. People with Spec. Needs. (2012) 642–649. http://link.springer.com/chapter/10.1007/978-3-642-31522-0_97.

[35] G.B. Moskowitz, Cognitive social psychology: The Princeton symposium on the legacy and future of social cognition, Ed., Psychology Press, Mahwah, NJ, 2013.

[36] M. Hoogendoorn, R.M. Van Lambalgen, J. Treur, Modeling Situation Awareness in human-like agents using mental models, in: Proc. Twenty-Second Int. Jt. Conf. Artif. Intell. Model., 2011: pp. 1697–1704.

[37] M.S. Gazzaniga, T.F. Heatherton, D.F. Halpern, S.J. Heine, Psychological Science, 3rd ed., WW Norton, New York, 2012.

[38] I. Oppenheim, S. Enjalbert, R. Dahyot, M. Pichon, Description of unified model of driver behaviour (UMD) and definition of key parameters for specific application to different surface transport domains of application, 2010. http://www.diva-portal.org/smash/record.jsf?pid=diva2:674066 (accessed April 1, 2018).

[39] I. Oppenheim, D. Shinar, S. Enjalbert, A. Amantini, Cacciabue C., F. Lai, M. Hjälmdahl, Peters B., Final report ITERATE. Deliverable No. 7.3. ITERATE (IT for Error Remediation And Trapping

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Emergencies) Consortium., 2012.

[40] T. Wheatley, D.. Wegner, Automaticity of Action , Psychology of, Elsevier Ltd, 2001. doi:0-08-043076-7.

[41] T. Wasserman, L.D. Wasserman, Automaticity and unconsciousness: What are they and what's the difference?, in: Depathologizing Psychopathol. Neurosci. Ment. Illn. Its Treat., Springer, 2016: pp. 67–77. doi:10.1007/978-3-319-30910-1.

[42] E.T. Panek, J.B. Bayer, S.D. Cin, S.W. Campbell, Automaticity, mindfulness, and self-control as predictors of dangerous texting behavior, Mob. Media Commun. 3 (2015) 383–400. doi:10.1177/2050157915576046.

[43] T. Rosenbloom, A. Shahar, A. Elharar, O. Danino, Risk perception of driving as a function of advanced training aimed at recognizing and handling risks in demanding driving situations, Accid. Anal. Prev. 40 (2008) 697–703. doi:10.1016/j.aap.2007.09.007.

[44] N.A. Stanton, G.H. Walker, M.S. Young, T. Kazi, P.M. Salmon, Changing drivers' minds: the evaluation of an advanced driver coaching system, Ergonomics. 50 (2007) 1209–1234. doi:10.1080/00140130701322592.

[45] J. Smith, Decision-making in midwifery: A tripartite clinical decision, Br. J. Midwifery. 24 (2016) 574–580. doi:10.12968/bjom.2016.24.8.574.

[46] A.A. Aziz, M.C.A. Klein, J. Treur, An Agent Model of Temporal Dynamics in Relapse and Recurrence in Depression, in: Int. Conf. Ind. Eng. Other Appl. Appl. Intell. Syst., Springer, Berlin, Heidelberg., 2009: pp. 36–45. doi:10.1007/978-3-642-02568-6_4.

[47] J. Treur, Dynamic Modeling Based on a Temporal-Causal Network Modeling Approach, in: Biol. Inspired Cogn. Archit., 2016: pp. 131–168.

[48] J. Treur, Network-oriented modeling and its conceptual foundations, in: Network-Oriented Model., Springer International Publishing, 2016: pp. 3–33. doi:10.1007/978-3-319-47874-6_12.

[49] J. Treur, Verification of temporal-causal network models by mathematical analysis, J. Comput. Sci. 3 (2016) 207–221. doi:10.1007/s40595-016-0067-z.

[50] A.A. Aziz, F. Ahmad, N. Yusof, A.F. Kabir, M.Y.S. Azmi, Formal analysis of temporal dynamics properties in anxiety states and traits, J. Telecommun. Electron. Comput. Eng. 8 (2016) 133–138. http://journal.utem.edu.my/index.php/jtec/article/view/1333 (accessed March 31, 2018).

[51] F. Ding, Combined state and least squares parameter estimation algorithms for dynamic systems, Appl. Math. Model. 38 (2014) 403–412. doi:10.1016/J.APM.2013.06.007.

[52] Y.-M. Chen, G. Kauffmann, C.A. Tremonti, S. White, T.M. Heckman, K. Kovač, K. Bundy, J. Chisholm, C. Maraston, D.P. Schneider, A.S. Bolton, B.A. Weaver, J. Brinkmann, Evolution of the most massive galaxies to z= 0.6 - I. A new method for physical parameter estimation, Mon. Not. R. Astron. Soc. 421 (2012) no-no. doi:10.1111/j.1365-2966.2011.20306.x.

[53] R. Aster, B. Borchers, C. Thurber, Parameter estimation and inverse problems, Academic Press, 2011.

[54] J. Treur, M. Umair, A Cognitive Agent Model using Inverse Mirroring for False Attribution of own actions to other agents, in: Mod. Approaches Appl. Intell., Springer, Berlin, Heidelberg, 2011: pp. 109–119. doi:10.1007/978-3-642-21827-9_12.

[55] G. Vidotto, D. Massidda, S. Noventa, Averaging models: Parameters estimation with the R-Average procedure, Psicológica Rev. Metodol. y Psicol. Exp. 31 (2010) 461–475. http://www.redalyc.org/html/169/16917002003/ (accessed April 1, 2018).