# Effects of Self-Assessed Ability and Driving Experience on Hazard Perception*

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**Abstract** The present study investigated the effects of self-assessed ability and driving experience on the ability to detect, evaluate and respond to hazards, namely, hazard perception. 86 participants took a video-based hazard perception task, using Tobbi T120 to record their eye movement. Before the experiment, participants first finished a self-reported scale and then they were divided into low ability and high ability group according to the mean score of their self-assessed ability in each driver group.

A 2 × 2 × 2 mixed design was employed, with driving experience and self-assessed ability as the between-groups factors and hazard type as the within-groups factor. 18 traffic video clips, shooting from drivers' perspective, were used and participants were asked to respond to overt hazard (visible) or covert hazard (partially invisible but urgent) quickly when they detected a potential one. Results showed there were no significant correlations between scores of drivers' self-assessed ability and their response latency, indicating both novice and experienced drivers have bad insight into their hazard perception ability. Generally, experienced drivers reacted to overt hazards and covert hazards faster than novice drivers and self-assessed ability did affect drivers' detection and reaction to hazards. Specifically, novice drivers, who rated their ability better, reacted to overt and covert hazards slower than their peers with low ability significantly. This suggests that novice drivers with high self-assessed ability may have a higher risk acceptance threshold, which has a negative effect on their hazard appraisal. Furthermore, no significant differences were found on hazard perception reaction time of experienced drivers with varying self-assessed ability. Eye movement data revealed that experienced drivers spent less time to detect hazards and fixated them longer than novice drivers. Compared with their peers with low ability, novice drivers with high self-assessed ability detected hazards slower and allocated less attention to them, which in turn reduced their safety margin in reaction time. This study suggests that self-assessed bias towards driving ability among different driver group should be reduced, at least properly measured, when it comes to hazard perception training and tests.

**Keywords** hazard perception, self-assessed ability, driving experience, overt hazard, covert hazard

## 1 Introduction

Hazard perception (HP) is the process of detecting, evaluating and responding to dangerous events on the road that have a high likelihood of leading to a collision (Crundall et al., 2012). Typically, HP is investigated by using dynamic traffic video clips, shooting from drivers' perspective. Drivers are asked to respond quickly when they detect a latent hazard. Many studies found novice drivers reacted to hazards slower than experienced drivers, and their visual strategies were relatively ineffective (Borowsky, Shinar, & Oron-Gilad, 2010; Huestegge, Skottke, Anders, Müsseler, & Debus, 2010). Two main reasons can explain the poor HP performance of novice or inexperienced drivers.

Firstly, due to lack of driving experience, novice drivers' situation awareness wasn't fully developed, thus making them difficult to change their visual strategies in different road environment flexibly (Underwood, 2007). Compared with experienced drivers, novice drivers weren't sensitive to hazards and detected them slower. Furthermore, novice drivers always scanned the area closer to the front of the car and didn't search hazards continually (Borowsky et al., 2010). Therefore, a hazard detected by an experienced driver may be ignored by a novice driver, especially when it appeared in the periphery or in unexpected locations.

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Secondly, hazard type may affect the discrimination validity between driver groups. Evidence could be seen in one study, where they found only 6 out of 31 video clips can effectively discriminate novice and experienced drivers (Sagberg & Bjørnskau, 2006). More recently, Crundall et al. found that some types of hazard differentiated experience more effectively than others and visual strategies of drivers with varying driving experience could reflect the differences of their HP ability (2012). Thus, in the present study, we'll explore drivers' response to different hazard types.

Despite of the two reasons discussed above, several studies using self-reported methods found drivers' self-assessed ability affected their driving behaviors. In fact, drivers, especially young novice drivers, often rated themselves as more skillful and underestimated their crash risk (De Craen, Twisk, Hagenzieker, Elffers, & Brookhuis, 2011; White, Cunningham, & Titchener, 2011). For example, novice drivers often rated themselves superior to both their peers and the average driver when it came to HP ability (Horswill, Waylen, & Tofield, 2004). By comparing self-assessed driving performance of novice and experienced driver with an average driver as well as drivers' real driving performance with the evaluation of an driving expert, (De Craen et al., 2011) found both novice and experienced drivers overestimated their driving ability. Recently, two studies using old drivers as participants found there were no significant correlations between old drivers' self-assessed HP ability and their performance on a video-based HP test, indicating they rated their HP ability unrealistically (Horswill, Anstey, Hatherly, Wood, & Pachana, 2011; Horswill, Sullivan, Lurie-Beck, & Smith, 2013). Therefore, it was expected that self-assessed ability may both affect novice and experienced drivers' HP performance.

As to our knowledge, little was known about the effect of self-assessed ability on different aspects of drivers' HP performance (i.e., hazard detection, hazard appraisal and hazard handling). Therefore, the aims of the present study were to investigate the effects of self-assessed ability and driving experience on drivers' HP performance by using a video-based HP task. The present study also investigated the effect of self-assessed ability on drivers' visual strategies by using eye tracking measures for all participants. We predicted that, regardless of hazard type, novice drivers with high self-assessed ability reacted to hazards slower than their peers with low ability and experienced drivers. Correspondingly, novice drivers with high ability would detect hazards slower and fixate them less time than their peers with low ability.

## 2 Methods

### 2.1 Participants

86 drivers (44 male) agreed to participate in the present study. 44 young novice drivers (24 male, age range: 19~27 years, *mean* age = 24.05, *SD* = 2.56), who had less than 1 year's driving experience (*M* = 8.8 months, *SD* = .22). 42 middle-aged experienced drivers (20 male, age range: 30~59 years, *M* = 44.62, *SD* = 8.21), who had more than 5 years' driving experience (*M* = 17.33, *SD* = 6.34). Chi-squared tests showed there were no significant differences in gender for each driver group. All drivers' visual version was normal or corrected-to-normal.

### 2.2 Materials

#### 2.2.1 Hazard perception scale

A 6 item-hazard perception scale of (White et al., 2011) was used to assess drivers' self-assessed HP ability. The content of all 6 items was same for novice and experienced drivers with a little difference in the instruction: "Compared with a typical novice driver/ experienced driver, how skillful are you at……?" The items were rated from 1 (much worse) to 7 (much better) with a mid-point of 4 (the same). The reliability (Cronbach's alpha) of the scale was .91.

#### 2.2.2 Hazard perception task

The HP task included 18 dynamic video clips (length from 9s to 21s). These clips were shot from drivers' perspective around Dalian urban and rural area along different roads under fine weather. The clips showed traffic situations where a potentially hazardous event was developing as the camera car was approaching. During the experiment, participants could see the front part of the camera car. All hazardous events involved other road users (e.g., cyclists). Hazards were split into two types according to their materialization. Overt hazards were totally visible in the process of materialization in front of drivers (e.g., a child walked into the driving lane), while covert hazards were partially invisible at the beginning of materialization and then abruptly appeared in front of drivers (e.g., a pedestrian walked into the driving lane from behind a parked lorry). Clips in each hazard type were somewhat matched for hazard content. The reliability of the HP task in the present study was acceptable (Cronbach’s alpha was .81).

After hazards were split, fifteen drivers with different age and driving experience were invited to assess those hazards in the clips and classified them. Each driver classified the 18 hazards either as an overt hazard or a covert hazard. Overall, the high agreements from the fifteen drivers confirmed our classification accuracy. As the clip length varied, participants weren’t able to predict the possible hazards without paying attention to the clips during the experiment.

### 2.3 Design

A 2 × 2 × 2 mixed design was employed in the present study. The between-groups factors were driving experience (novice driver vs. experienced driver) and self-assessed ability (low vs. high). The within-groups factor was hazard type (overt hazard vs. covert hazard).

### 2.4 Procedure

After giving informed consent, participants first finished a demographic questionnaire and the HP scale, and then they undertook the HP task. Eye movements of participants were recorded using Tobbi T120 eye tracker, which sample at 120Hz. The viewing distance was 65cm from the screen. After calibrating their gaze points, participants took 4 practice clips, presented by Tobbi Studio 3.0. The instruction was “You will be showed some real traffic video clips, imagine you are the driver in the clips. When you detect a potential hazard that force you to slow down or change your driving course, click the left mouse button quickly”. If participants didn’t completely understand the instruction, they could take the practice clips again. Finally, after another calibration, 14 video clips were randomly assigned to each participant on a 17-inch monitor at a resolution of 1280 × 720. The experiment lasted about 25 minutes.

### 2.5 Date analysis

A hazardous AIO was created for each hazard, using Tobbi Studio’s Dynamic Area of Interest (AIO) tool. The hazardous AIO covered the process from hazard onset to the button press, which was resembled to (Yeung & Wong, 2015)’s method (see fig.1). Response latency was made up of time to first fixation (TFF) and HP reaction time (HPRT), representing hazard detection time and hazard appraisal time respectively. Therefore, the dependent variables included response latency, TFF, HPRT and total fixation duration (TFD). HPRT meant the time from participants’ first fixation on the hazardous AIO to the last moment when they clicked the button to react (Mackenzie & Harris, 2015). TFF meant the time from hazard onset to participants first fixated the hazardous AIO. TFD meant the amount of attention devoted to the hazardous AIO after participants first fixated it.

In our study, we first examined the relationship between scores of participants’ self-assessed ability and their response latency to see whether they had an accuracy insight into their HP ability. We then divided participants into high and low ability group to further examine the relationship. Finally, unless otherwise stated, a 2 × 2 × 2 mixed ANOVA was run for all measures.

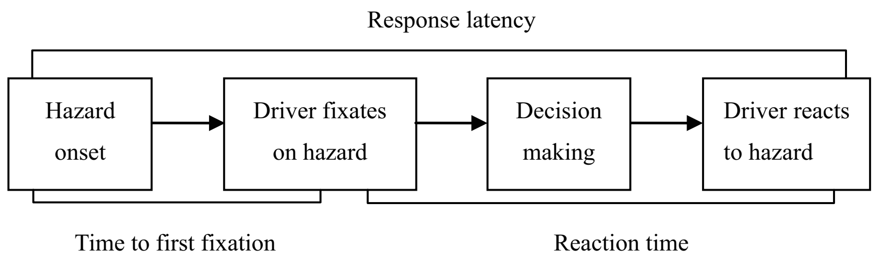


**Fig.1 Illustration of perception, reaction, and total response times (Yeung & Wong, 2015)**

## 3 Results

First, No significant correlations were found between the score of drivers' self-assessed ability and their response latency. Specifically, for novice drivers, the correlation with response latency on covert hazards was $r$ = .06, $p$ > .05, and overt hazards $r$ = .12, $p$ > .05. For experienced drivers, the correlation with response latency on covert hazards was $r$ = -.19, $p$ > .05, and overt hazards $r$ = .12, $p$ > .05. These indicate both novice and experienced drivers have bad insight into their HP ability, thus needing to explore the effect of self-assessed ability in detail.

Overall, the score of self-assessed ability of experienced drivers ($M$ = 5.32, $SD$ = 1.18) was higher than that of novice drivers ($M$ = 4.34, $SD$ = .90), $t$ = -4.31, $p$ < .01. Drivers were then divided into low and high ability group by the mean score of self-assessed ability in each group. For novice drivers ($M$ = 4.34), we had 23 novice drivers with low self-assessed ability and 21 novice drivers with high ability. Independent-samples t test showed high ability drivers ($M$ = 5.06, $SD$ = .59) scored higher than low ability drivers ($M$ = 3.69, $SD$ = .56), $t$ = -7.93, $p$ < .01. For experienced drivers (mean = 5.32), we had 20 experienced drivers with low ability and 22 experienced drivers with high ability. Independent-samples t test showed high ability drivers ($M$ = 6.28, $SD$ = .67) scored higher than low ability drivers ($M$ = 4.26, $SD$ = .52), $t$= -10.85, $p$< .01.

### 3.1 Hazard perception reaction time

Mean HPRT, TFF and TFD in different groups were showed in tab 1.

A 2 × 2 × 2 analysis of variance (ANOVA) compared mean HPRT in different groups. The main effect of driving experience was significant ($F$ (1, 82) = 11.98, $p$ < .01, $\eta^2$ = .127), experienced drivers reacted to hazard faster than novice drivers. The main effect of hazard type was significant ($F$ (1, 82) = 646.65, $p$ < .01, $\eta^2$ = .887), drivers reacted to covert hazards faster than overt hazards.

**Tab 1 Mean HPRT, TFF and TFD in different groups ($M$± $SD$)**

| Dependent Variable | Driver Group | Overt hazard | | Covert hazard | |
|---|---|---|---|---|---|
| | | Low ability | High ability | Low ability | High ability |
| HPRT(s) | Novice | 2.05 ± .48 | 2.33 ± .43 | 1.09 ± .26 | 1.30 ± .47 |
| | Experienced | 1.72 ± .48 | 1.94 ± .48 | 1.07 ± .33 | .92 ± .28 |
| TFF(s) | Novice | .12 ± .20 | .15 ± .24 | .14 ± .11 | .25 ± .20 |
| | Experienced | .05 ± .05 | .08 ± .07 | .14 ± .17 | .07 ± .06 |
| TFD(s) | Novice | 3.83 ± .69 | 3.36 ± .91 | 2.55 ± .50 | 2.43 ± .65 |
| | Experienced | 4.02 ± .57 | 4.09 ± .49 | 2.84 ± .30 | 2.92 ± .31 |

The interaction between driving experience and hazard type was significant ($F$ (1, 82) = 5.04, $p$ < .05, $\eta^2$ = .058). Further contrast showed HPRT on overt hazards, experienced drivers reacted faster than novice drivers ($F$ (1, 84) = 11.46, $p$ < .01, $\eta^2$ = .120); HPRT on covert hazards, experienced drivers reacted faster than novice drivers ($F$ (1, 84) = 6.78, $p$ < .05, $\eta^2$ = .075). The interaction between self-assessed ability and hazard type was significant ($F$ (1, 82) = 8.54, $p$ < .01, $\eta^2$ = .094). Further contrast showed only HPRT on overt hazards, low ability drivers reacted faster than high ability drivers ($F$ (1, 84) = 4.68, $p$ < .05, $\eta^2$ = .053).

The interaction among all factors was significant ($F$ (1, 82) = 4.40, $p$ < .05, $\eta^2$ = .051). Simple simple effect test showed HPRT on overt hazards, only for novice drivers, the effect of self-assessed ability was significant ($F$ (1, 42) = 4.11, $p$ < .05, $\eta^2$ = .089), low ability drivers reacted faster than high ability drivers; HPRT on covert hazards, only for novice drivers, the effect of self-assessed ability was marginally significant ($F$ (1, 42) = 3.67, $p$ = .062, $\eta^2$ = .080), low ability drivers reacted faster than high ability drivers.

### 3.2 Time to first fixation

A 2 × 2 × 2 analysis of variance (ANOVA) compared mean TFF in different groups. The main effect of driving experience was significant ($F$ (1, 82) = 8.68, $p$ < .01, $\eta^2$ = .096), experienced driver detected hazards faster than novice driver. The main effect of hazard type was significant ($F$ (1, 82) = 7.58, $p$ < .01, $\eta^2$ = .085), drivers detected overt hazards faster than covert hazards.

The interaction among all factors was significant

($F$ (1, 82) = 5.37, $p$ < .05, $\eta^2$ = .061). Simple simple effect test showed TFF on overt hazards, for novice and experienced drivers, effects of self-assessed ability weren't significant ($F$ = .19, $p$ = .66; $F$ = 2.39, $p$ = .13); TFF on covert hazards, only for novice drivers, the effect of self-assessed ability was significant ($F$ (1, 42) = 5.47, $p$ < .05, $\eta^2$ = .115), low ability drivers detected covert hazards faster than high ability drivers.

### 3.3 Total fixation duration

A 2 × 2 × 2 analysis of variance (ANOVA) compared mean TFD in different groups. The main effect of driving experience was significant ($F$ (1, 82) = 12.85, $p$ < .01, $\eta^2$ = .135), experienced drivers fixated hazards longer than novice drivers. The main effect of hazard type was significant ($F$ (1, 82) = 659.90, $p$ < .01, $\eta^2$ = .889), drivers fixated overt hazards longer than covert hazards.

The interaction between self-assessed ability and hazard type was significant ($F$ (1, 82) = 4.66, $p$ < .05, $\eta^2$ = .054). Further contrast showed TFD on overt and covert hazards, effects of self-assessed ability weren't significant ($F$ = 1.48, $p$ = .22; $F$ = .01, $p$ = .97). The interaction among all factors was significant ($F$ (1, 82) = 4.59, $p$ < .05, $\eta^2$= .053). Simple simple effect test showed TFD on overt hazards, only for novice drivers, the effect of self-assessed ability was significant ($F$ (1, 42) = 4.06, $p$ < .05, $\eta^2$ = .088), low ability drivers fixated overt hazard longer than high ability drivers; TFD on covert hazards, for novice and experienced drivers, effects of self-assessed ability weren't significant ($F$ = .35, $p$ = .56; $F$ = .72, $p$ = .40).

## 4 Discussions

The present study determined to explore the effects of self-assessed ability and driving expedience on drivers' HP performance. Firstly, no significant correlations were found between drivers' self-assessed ability and their response latency. This finding was in line with previous studies showing that both novice and experienced drivers couldn't assess their HP ability correctly (De Craen et al., 2011; Horswill et al., 2013). Interestingly, compared with novice drivers, experienced drivers' self-assessed ability was negatively correlated with their response latency on covert hazards, though the correlation wasn't significant. This suggested novice and experienced drivers with varying self-assessed ability may overestimate different aspects of their HP ability.

Secondly, experienced drivers reacted to hazards faster than novice drivers, which were consistent with previous studies (Borowsky et al., 2010; Huestegge et al., 2010). This could be explained by situation awareness of potential road hazards (Underwood, 2007). Situation awareness developed as drivers gained more driving experience, and it in turn would guide drivers' visual attention to the critical area where a potential hazard may occur, thus facilitating their hazard detection and reaction. In addition, novice drivers, who subjectively rated their HP ability better, reacted to hazards slower than their peers and experienced drivers. No significant differences were found among experienced drivers with varying self-assessed ability.

Thirdly, hazard type did affect HPRT. Drivers reacted to covert hazards faster than overt hazards. This can be explained by time pressure and outcome fatality (Borowsky & Oron-Gilad, 2013). According to the definition, covert hazards were more urgent and left less time for drivers to appraise their outcome fatality. On the contrary, without any time pressure, driver have enough time to monitor the materialization of overt hazards and appraise their outcome fatality, which may in turn lower drivers' alertness and delay their preparatory actions to these hazards.

With regard to driving experience, novice drivers with high ability reacted to overt and covert hazards slower than low ability drivers. (Deery, 1999) found novice drivers, who were overconfident about their driving ability, had a higher risk acceptance threshold. Support for this idea could also be found in our data, as most of novice drivers with high ability rated their ability of responding to hazard quickly "good" (compared with "much better"), indicating they may have a high risk acceptance threshold rather than overestimate their hazard handling ability. Therefore, novice drivers with high ability reacted to overt hazards slower because these hazards may not be dangerous or they simply didn't appraise them as hazardous, though overt hazards were more frequent in real driving. Due to the nature of covert hazards, novice drivers may have difficulty in detecting and processing them. If novice drivers overestimated their ability, they may have delayed reaction to these partially hidden but urgent hazards.

Although experienced drivers with low ability reacted to overt hazards faster than high ability drivers, they reacted to covert hazards slower than high ability drivers. The differences weren't significant in both conditions. One possible explanation for these contradictory results may be that experienced drivers with high ability were overconfident about their hazard handling ability, when they confronted an overt hazard in driving. Because most of these drivers rated their ability of responding to hazard quickly "much better", while most of their peers with low ability rated this ability "the same". With regard to covert hazard, time pressure may still play a significant role in reaction of experienced drivers with high ability (Borowsky & Oron-Gilad, 2013). It's also possible that experienced drivers with high ability may have a greater awareness of covert hazards as their eye movement data suggested (i.e. earlier detection and longer fixations).

First fixation made by novice driver on overt and covert hazards was slower than experienced driver. (Crundall et al., 2012) found inexperienced drivers were slower to first fixate the critical stimuli than experienced drivers. It meant the time novice driver spent to detect hazards was longer, and this may partially explain their delays in reaction time (Mackenzie & Harris, 2015). Furthermore, novice drivers with high ability spent more time to detect hazards than their peers and experienced drivers, especially on covert hazards. This indicated hazard detection may suffer from the negative effect of novice drivers' overestimation of their HP ability.

Finally, experienced drivers fixated overt hazard and covert hazards longer than novice drivers. This was in line with (Crundall et al., 2012)'s findings, where they found total dwell time upon hazards of experienced drivers was longer than inexperienced drivers. It is also possible that hazards evoked longer fixation duration and novice drivers were disproportionately affected (Chapman & Underwood, 1998). Notably, self-assessed ability interacted with hazard type, with low ability drivers fixated hazards longer than high ability drivers. Specifically, novice drivers with high ability fixated overt hazards less time than their peers with low ability. This meant relatively shorter fixation duration on hazards may reflect failure to process them, and this may lead to a delayed reaction too.

To summarize, different drivers' self-assessed ability and its interaction with hazard type can influence their HP performance. In other words, drivers' self-assessed ability didn't correspond to their HP performance. This should be taken seriously when it comes to driving safety of drivers with different age and driving experience. Although novice drivers can benefit from systematic HP training, it's impossible to increase their driving experience in a short time. However, the present study hinted us that self-assessed bias towards driving ability among different driver group should be measured properly during hazard perception training and tests. Also, measures should be taken to reduce novice drivers' self-assessed bias in hazard appraisal and experienced drivers' self-assessed bias in hazard handling.

Both experienced and novice drivers' eye movement data can reflect the results of their HP performance. Overall, novice drivers detected hazards slower and allocated less attention to them than experienced drivers. The underlying reason for this would be that novice drivers haven't been driving long enough to develop flexible visual strategies. In addition, compared with their peers with low ability, visual strategies of novice drivers with high ability were less effectively, which in turn may shorten their safety margin in reaction time. These findings can also be used in hazard perception training by guiding novice drivers where to look and how to detect hazards.

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# 自我评估的能力与驾驶经验对危险知觉的影响

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**摘 要** 结合反应时和眼动研究方法，采用驾驶经验 2（新手，有经验）× 自我评估的能力 2（高，低）× 危险类型 2（明显，隐藏）的混合实验设计，探索驾驶员驾驶能力的自我评估和驾驶经验对危险知觉及视觉注意的影响。采用驾驶能力量表和基于动态交通视频的危险知觉任务对 86 名驾驶员测试，并使用 Tobbi T120 记录眼动数据。结果发现，新手和有经验驾驶员自我评估的能力与危险知觉反应时间之间相关不显著，这说明两组驾驶员对自己驾驶能力的认识和评估不准确。有经验驾驶员对两类危险的反应比新手快。新手自我评估的能力过高，他们对两类危险的反应比同龄驾驶员和有经验驾驶员慢。然而，有经验驾驶员自我评估的能力与危险知觉反应时间之间不存在显著差异。此外，与新手相比，有经验驾驶员对两类危险的首次注视较快，总注视时间更长。与同龄驾驶员相比，新手自我评估的能力过高，他们对危险的首次注视较慢，对危险的总注视时间更少。这些研究结果表明，新手自我评估的能力过高，可能会提高他们的风险接受阈限，由此降低了他们对危险的反应速度。未来驾驶训练应当采取措施减少新手对驾驶能力的自我评估偏见，改善他们的视觉搜索模式以降低事故风险。

**关键词** 危险知觉 驾驶经验 自我评估的能力 明显危险 隐藏危险