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Driving School Programs and Influences on Risk Aversion from Sex Differences in Brain Structure and Hormones

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Sammendrag: Denne artikkelen utforsker hvordan kjønnsforskjeller i risikoaversjon påvirker kjøring og kjøreopplæring, og fremhever behovet for kjønns-spesifikke strategier på grunn av forskjeller i risikotakende atferd. Disse forskjellene påvirker både akademisk prestasjon på teoriprøver og trafikksikkerhet. Artikkelen gjennomgår nyere litteratur om hvordan hjernestruktur og hormoner påvirker læringsstiler og kjøreatferd, og argumenterer for kjønnsdifferensierte undervisningsprogrammer. Den undersøker hvordan GDE-matrisen kan implementeres i norsk føreropplæring, med fokus på å integrere kjønnsforskjeller i opplæringen. Typisk bidrar østrogen til høyere risikoaversjon og forsiktig kjøring blant kvinner, mens testosteron fremmer mer risikofylt kjøring blant menn. Disse biologiske forskjellene antas også å påvirke akademisk innsats, hvor kvinner generelt studerer mer for å unngå dårlige resultater, mens overdrevent selvsikre menn ofte legger mindre innsats i forberedelsene. Artikkelen foreslår å tilpasse undervisningsmetoder til forskjellige læringsstiler på nivå 1 og 4 i GDE-matrisen, og oppfordrer til forskning på kjønns-tilpassede kjøresimulatorer for å adressere stereotype atferder i stressede situasjoner.

Nøkkelord: risikovilje, trafikkopplæring, kjønnsforskjeller, hjernestruktur, hormoner, læringsstiler, GDE-matrisen, trafikksikkerhet

Abstract: This paper explores how sex differences in risk aversion affect driving and driving education, highlighting the need for sex-specific strategies due to differences in risk-taking behaviours. These differences impact both academic performance in theory exams and driving safety. The research reviews recent literature on how brain structure and hormonal influences affect learning styles and driving behaviour, advocating for sex-differentiated teaching programs. It examines the GDE matrix's implementation in Norwegian driver education, focusing on integrating sex differences into training. Typically, estrogen contributes to higher risk aversion and careful driving among females, while testosterone promotes riskier driving behaviours among males. These biological differences presumably also influence academic efforts, with females generally studying more to avoid poor results, while overconfident males often put less effort into preparation. The paper suggests adapting teaching methods to suit different learning styles at Levels 1 and 4 of the GDE matrix and calls for future research on sex-adapted driving simulators to address stereotypical behaviours in stressful situations.

Keywords: risk aversion, driving education, sex differences, brain structure, hormones, learning styles, GDE matrix, traffic safety

Introduction

The study of sex differences in brain structure and hormonal influences has garnered significant attention in recent years and is believed to contribute to variations in learning styles, academic effort, and performance between males and females (see e.g. Andreano & Cahill, 2009; Cahill, 2006; Pawluski et al., 2020). Studies show that females are generally more risk-averse than males, which is linked to differences in brain structure and hormonal influences.

The study by Harris and Jenkins (2006) focuses on perceptions of negative outcomes and enjoyment from risky activities. It highlights that women perceive higher probabilities of negative outcomes and lower enjoyment from risky activities, which contributes to their lower propensity for risk-taking. Women also perceive the potential negative outcomes of risky behaviours as more severe, particularly in gambling and health domains. This perception further mediates their lower propensity for risk-taking in these areas.

In the academic context, these findings may explain two stylised facts on sex differences in academic performance and effort: that females generally perform better than males (see e.g. Dayiolu & Türüt-asik, 2007; Klingsieck et al., 2012; Trueman & Hartley, 1996; Voyer & Voyer, 2014), but also spend more time studying (Gershenson & Holt, 2015; see also Borghans et al., 2009; Dawson, 2023). The latter, which can be interpreted as an attempt to minimise the risk of bad grades, indicates a higher degree of loss aversion in females compared to males. More loss-averse implies more risk-averse.

The issue of risk aversion is particularly relevant for driving school programmes to consider, where educational strategies need to address sex differences in risk-taking not only for academic performance (pass rates of theory exams), but also with respect to driving safety related to sex differences in risk-taking behaviours in driving situations.

The *aim* of this paper is to provide evidence from recent literature on how the interplay between brain structure and hormonal influences affects learning styles and risk aversion, thereby raising awareness of the potential need for sex-differentiated teaching programmes. This paper explores these interconnected aspects, with a special focus on risk aversion, to provide a comprehensive understanding of how biological factors contribute to sex differences in behaviour in these respects.

The paper proceeds as follows: Sections 2 and 3 establish facts about sex differences in traffic safety and traffic school exam results respectively, to provide necessary background. Section 4 provides a brief overview of the Goals for Driver Education (GDE) matrix, developed to structure and improve driver education, serving as a framework into which sex-differentiated teaching programmes can be adapted. Sections 5.1 to 5.6 present selected literature on biological sex differences and their impacts on behaviour, followed by an overview of sex differences in driving behaviour, illustrating the biologically induced behavioural differences. Section 6 suggests tailored educational strategies for driving school programmes to be implemented in the GDE matrix. Section 7 discusses and concludes.

Sex and Traffic Safety

Males cause more accidents overall, but this is partly because they drive more miles compared to females, who have a higher accident rate per mile driven (Bruckheim & Patel, 2024). Despite this, men are responsible for a significantly higher number of fatal accidents or severe injuries per capita. Data from the Insurance Institute for Highway Safety (IIHS) (2024) indicate that many more men than women die each year in motor vehicle crashes.

So, even if men typically drive more miles, they are also more likely to engage in risky driving behaviours, such as not using seat belts, driving while impaired by alcohol, and speeding. Consequently, crashes involving male drivers tend to be more severe than those involving female drivers, where "the fatal crash involvement rate per 10,000 drivers for men was three times that for women (5.3 vs 1.7) and was highest among teenagers." (Li et al., 1998, p. 379).

However, females are more likely than males to be killed or injured in *crashes of similar severity* (Kahane, 2013). The types of vehicles men drive and the circumstances of their crashes contribute to this decreased risk (Brumbelow & Jermakian, 2022). Notably, the difference in fatality risk between male and female drivers has diminished in newer vehicles due to improvements in crashworthiness and restraint design (Noh et al., 2022). These findings are based on an analysis of data from the U.S. Department of Transportation's Fatality Analysis Reporting System (FARS).

In Norway, sex differences in traffic accidents are pronounced, with men being significantly more likely to be involved in fatal and severe accidents. Statistics indicate that 73% of road traffic fatalities are men, while only 27% are women. Similarly, 65% of those severely injured in traffic accidents are male, compared to 35% female (Statistics Norway, 2024). These figures align with global trends, where men typically engage in riskier driving behaviours and drive more miles than women.

Sex and Driving School Exam Results

Regarding sex differences in driving school exam results, both practical and theoretical, the following observations have been made across various countries.

In France, for instance, the pass rate for the practical driving test is significantly lower for women (53.4%) compared to men (62.7%), despite women performing better than men in the theoretical test (70% pass rate for women versus 56% for men) (Anne et al., 2024). This trend is not unique to France; similar patterns are seen in the United Kingdom and Finland, where women also have lower pass rates for the practical exam but perform equally well or better in the theoretical exam (Statista, 2024; Traficom, 2024).

In Norway, data show that men have a higher pass rate in the practical driving test compared to women, while women tend to perform better in the theoretical test: "Females studied more theory, pursued training in a more structured manner, practised more elements of driving in several different environments, and participated more extensively in driving school instruction" (Nyberg and Gregersen, 2007).

These disparities may be influenced by various factors, including societal stereotypes, differences in learning styles, and test anxiety.

However, the results also align with stylised facts about sex differences in academic performance and effort: females obtain better results (see references above).

Adapting to The GDE Matrix Framework

The GDE Matrix (Goals for Driver Education) is a framework developed to structure and improve driver education (Hatakka et al., 2002). It was developed as part of the EU-supported GADGET project and is used in many European countries, including Norway.

The GDE matrix divides driver education into four levels, each covering different aspects of driving skills and safety. In the following, we provide a brief overview of this overarching framework for traffic education and point out which areas may be suitable for sex-adapted training. There are four levels in the GDE Matrix.

- Level 1: Vehicle Handling
  - This level focuses on the basic skills required to control the vehicle, such as steering, braking and gear shifting.
- Level 2: Traffic Rules and Situational Understanding
  - Here, students learn to understand and follow traffic rules, as well as interpret and react to various traffic environments and situations.
- Level 3: Travel-Related Decisions
  - This level deals with decisions related to planning and executing trips, including route choices, timing and risk assessment.
- Level 4: Personal Goals and Attitudes
  - Level 4 focuses on how personal values, attitudes and lifestyle affect driving habits and risk willingness. This includes self-assessment and reflection on one's own driving.

The 2010 revision of the Goals for Driver Education (GDE) matrix (Keskinen et al., 2010) expanded its scope to include a greater emphasis on personality factors, self-awareness and emotional regulation within driver education. This update underscored the significance of sex differences in driving behaviour and risk perception.

Research indicates that males typically exhibit higher risk tolerance and a greater propensity for risk-taking behaviours in traffic compared to females (Hatakka et al., 2002). By integrating these insights, driver education programmes can be tailored to address the specific needs and characteristics of different sexs, thereby enhancing overall traffic safety.

It can be adapted to account for such differences in the following areas:

Risk Willingness: The fact that men tend to be more willing to take risks than women can be addressed at Level 4 of the GDE matrix by focusing on attitudes and risk understanding. For example, training can include modules that highlight the dangers of overconfidence and risky behaviour, especially targeted at male students.

Learning Styles: Women may benefit from more structured and collaborative learning environments, while men may thrive better with practical and experiential methods (see section 5.6). This can be implemented at Levels 1 and 2 by adapting teaching methods to different learning styles.

Feedback and Assessment: Frequent reality checks and personal feedback can help male students gain a more realistic understanding of their skills and areas for improvement. This can be integrated at all levels of the GDE matrix.

Selected Literature on Sex Differences

Biological Influences on Risk Aversion: Brain Structure and Hormones

Sex differences in brain structure and hormonal influences play a significant role in shaping behaviours, including risk aversion, which in turn is likely to affect driving behaviour as well as academic effort and performance.

This section reviews key findings from recent research on the biological and psychological underpinnings of these differences.

A study by Lee et al. (2008) titled "Sex-Related Differences in Neural Activity During Risk Taking: An fMRI Study" investigated the neural mechanisms underlying sex differences in risk-taking behaviour using functional magnetic resonance imaging (fMRI). The researchers found that women exhibited stronger activation in the right insula and bilateral orbitofrontal cortex (OFC) compared to men during risk-taking tasks. Additionally, women showed stronger neural responses in the precentral, postcentral, and paracentral regions following punishment feedback. These findings suggest that women engage more neural resources in evaluating and processing risks, which may explain their generally more conservative risk-taking behaviour.

The review by Orsini et al. (2022) on "Regulation of Sex Differences in Risk-Based Decision Making by Gonadal Hormones: Insights from Rodent Models" explores how gonadal hormones influence sex differences in risk-based decision-making in rodents. The study highlights the role of oestrogen and testosterone in modulating risk-taking behaviours. It concludes that hormonal differences significantly contribute to the observed sex differences in risk-taking, with oestrogen generally promoting risk aversion and testosterone promoting risk-taking. This review provides insights into the biological mechanisms that may underlie sex differences in human risk-taking behaviour.

Dawson (2023) examines sex differences in risk-taking behaviour, revealing that women are generally more risk-averse than men due to heightened sensitivity to potential losses. The study suggests that women's greater loss aversion and lower financial optimism account for their lower propensity to take risks compared to men. This research highlights the psychological factors that contribute to sex differences in risk-taking.

A systematic review by Molins et al. (2022) investigates the genetic bases of risk and loss aversion, focusing on polymorphisms related to the serotonergic and dopaminergic pathways. The review finds that genetic variations, particularly those affecting dopamine and serotonin receptors, are linked to individual differences in risk aversion and loss aversion. This study provides a comprehensive overview of the genetic factors that may influence risk-taking behaviour.

Research indicates that there are sex differences in dopamine receptor expression and function. For example, men and women show differences in the density and distribution of dopamine receptors in various brain regions. These differences can influence behaviours and susceptibility to neuropsychiatric disorders (Gramling, 2006; Williams et al., 2021).

Similar sex differences are observed in the serotonergic system. Variations in serotonin receptor genes can affect mood regulation and risk for disorders such as depression and anxiety, with women generally being more susceptible to these conditions (Lafta et al., 2024). These polymorphisms – different forms, genetic variations within a population – can influence how these neurotransmitters are processed and utilised in the brain, and affect risk aversion among females (Heitland et al., 2012).

Harris and Jenkins (2006) investigate the psychological and perceptual factors that underlie sex differences in risk assessment and risk-taking behaviour. They find that women tend to perceive higher probabilities of negative outcomes and anticipate lower levels of enjoyment from risky activities, which partially accounts for their lower propensity for engaging in risk across areas such as gambling, health, and recreation. This research offers valuable insights into the cognitive processes that shape sex-specific tendencies towards risk-taking.

A paper by Dreber and Hoffman (2010) examines the biological underpinnings of sex differences in risk aversion and competitiveness, focusing on hormonal influences and evolutionary perspectives. The study suggests that evolutionary pressures and hormonal differences, particularly in testosterone and estrogen levels, contribute to the observed sex differences in risk-taking and competitive behaviours. This research integrates findings from evolutionary theory, animal behaviour, endocrinology, and neuroscience to explain why men and women differ in these economic preferences.

A study by Wu et al. (2020) titled "Neural Signatures of Gender Differences in Interpersonal Trust" uses fMRI to investigate the neural mechanisms underlying sex differences in interpersonal trust. The researchers found that men showed higher activation in brain regions associated with reward and self-referencing, while women showed decreased activation in regions related to social bonding with increasing risk. This indicates higher sensitivity to social risk in women.

Mehta and Prasad (2015) review the dual-hormone hypothesis, which posits that testosterone's role in status-relevant behaviour depends on cortisol levels, a hormone released in response to stress. The review covers evidence for the hypothesis in relation to dominance, aggression, social status, risk-taking, and economic decision-making. It also discusses contextual and individual difference moderators of dual-hormone associations with behaviour and outlines key directions for future research.

Sapienza et al. (2009) investigate the relationship between testosterone levels and financial risk aversion among MBA students. The study finds that higher levels of circulating testosterone are associated with lower risk aversion among women, but not men. The study also shows that testosterone levels and risk aversion predict career choices, with individuals high in testosterone and low in risk aversion more likely to choose risky careers in finance.

In a study of the relationship between testosterone, cortisol, and financial decisions in naïve investors, Nofsinger et al. (2018) find that testosterone levels are positively related to excess risk-taking, while cortisol levels are negatively related. The study supports the dual-hormone hypothesis, showing that the testosterone-to-cortisol ratio is significantly related to loss aversion.

Additionally, financial success is linked to higher post-trial testosterone and cortisol levels, indicating a positive feedback loop.

In a longitudinal study, Peper et al. (2018) examine the development of risk-taking behaviour and its relation to sex steroid hormones in participants aged 8–29 years. The study finds that increased testosterone and estradiol levels are associated with higher risk-taking behaviour and impulsive personality traits, but lower avoidance-like personality traits. The study demonstrates that risk-taking peaks in mid-to-late adolescence and suggests that sex hormones accelerate this maturational process.

Biassoni et al. (2016) explore the impact of ovarian hormones on risky driving behaviour in women. It was found that women are more risk-averse during their high-fertility phase compared to other phases of their menstrual cycle. The study suggests that fluctuations in ovarian hormones, particularly oestrogen and progesterone, influence risk-taking behaviour, with higher levels of these hormones associated with increased caution and risk aversion.

Table 11.1

Summary of biological structures and their effects

Biological structure	Effect
Right insula	Stronger activation in women during risk-taking tasks
Bilateral orbitofrontal cortex (ofc)	Stronger activation in women during risk-taking tasks
Precentral, postcentral, and paracentral regions	Stronger neural responses in women following punishment feedback
Estrogen	Promotes risk aversion
Testosterone	Promotes risk-taking
2D:4D ratio	Higher prenatal testosterone levels associated with greater risk-taking and competitiveness
Facial masculinity	Higher levels of pubertal testosterone linked to increased competitiveness and risk-taking
Circulating testosterone	Higher levels associated with greater risk-taking and competitive behaviors
Handedness and footedness	Related to risk preferences and competitive behaviors due to brain lateralization influenced by prenatal hormone exposure
Cortisol	Reduces risk-taking
Testosterone-to-cortisol ratio	Significantly related to loss aversion
Estradiol	Increases risk-taking behavior and impulsive personality traits, decreases avoidance-like personality traits

Evolutionary Causes of Sex Differences in Risk Aversion

Sex differences in risk aversion have been widely studied, with evolutionary theories providing significant insights into these behavioural traits. One prominent theory is based on sexual selection, which posits that males and females have evolved different risk-taking behaviours due to differing reproductive strategies. Males, who historically competed for access to females, may have evolved to take greater risks to increase their reproductive success. This is supported by evidence showing that men are generally more willing to engage in risky behaviours compared to women (Apicella et al., 2008).

Parental investment theory also plays a crucial role in explaining these differences. Females typically invest more in offspring through gestation and child-rearing, leading to a greater emphasis on survival and risk aversion to protect their investment (Trivers, 1972). This theory suggests that women have evolved to be more cautious and risk-averse to ensure the survival of their offspring.

In the same vein, Zuckerman (1994) noted that women produce higher levels of the enzyme monoamine oxidase than men. This enzyme inhibits sensation seeking and hence inhibits risk-taking behaviour. Witt (1994) argued that sex differences in risk-taking are a product of evolution, with women developing higher risk intolerance due to their greater responsibility for reproduction and child-caring.

Additionally, as noted above, hormonal influences, such as testosterone, have been linked to risk-taking behaviours. Higher levels of testosterone in males are associated with increased risk-taking and competitive behaviours (Dekel & Scotchmer, 1999). These biological factors, combined with evolutionary pressures, contribute to the observed sex differences in risk aversion.

Cultural and social factors also interact with these evolutionary predispositions. For instance, societal norms and expectations can amplify or mitigate inherent risk-taking behaviours. Studies have shown that in matrilineal societies, where women hold more power and status, the sex gap in risk aversion is significantly reduced (Gneezy et al., 2009).

Sociocultural Reasons

In an early study, Tuddenham (1952) found that risk-taking among men made them popular, while the opposite was true for women. Slovic (1966) suggested that pressure and social expectations during childhood may explain sex differences. Similarly, Flynn et al. (1994) found that socio-political factors (power and status), which favour men, induce increased risk tolerance.

Stark and Zawojska (2015, p. 84) "conjecture that the observed difference between single women and single men in attitudes towards risk is related to the higher value that single men assign to social status than do single women". By correlating social status with relative wealth, they showed "how an intensified distaste at experiencing low relative wealth reduces relative risk aversion, which, in turn, results in a higher propensity to resort to risky behaviour" (p. 84). The authors attributed sex-specific behaviours to different evolutionary selective pressures among women and men.

A different approach was taken by Morgenroth et al. (2018). Surveying a total of 238 people, they "investigated whether risk-taking measures inadvertently focus on behaviours that are more normative for males, resulting in the overestimation of sex differences" (p. 744). Using various traditional risk measures, they found that "differences in normativity are reflected in sex differences in self-reported risk-taking" (p. 744). They further claimed to provide evidence that "researchers overlook more stereotypically feminine forms of risk-taking by inadvertently using more male-typical forms in measurement" (p. 750). They did not claim, however, that men and women have identical risk profiles or that women are just as likely as men to take risks but merely stated that "feminine forms of risk-taking" are overlooked by researchers.

For example, they referred to literature showing that "women are as well-represented as men in certain forms of physically risky heroism (living kidney donation, Peace Corps) that are less dependent on physical prowess than acts of heroism in which men dominate (e.g. Carnegie Hero Medal recipients)" (p. 751).

Byrnes et al. (1999) compare the risk-taking tendencies of male and female participants in 150 studies. The studies were coded with respect to self-reported versus observed behaviours, task content, and age levels. They found greater risk-taking behaviours in male participants in 14 out of 16 types but concluded that the sex differences varied with context and age level.

Moreover, intellectual risk-taking and physical skills "produced larger sex differences than others" (p. 367), intellectual risk-taking involving tasks that required mathematical or spatial reasoning skills. In this category, "participants were mainly concerned about getting stuck or exposing their lack of skill when they fail" (p. 371). This indicates that females are more motivated by avoiding failure than by achieving success – that is, more loss averse than males in the context of academic achievement.

In an economic context, Watson and McNaughton (2007) found women to be more risk averse than men when choosing investment plans regarding their retirement benefits.

As noted, the results obtained by Byrnes et al. (1999) are consistent with loss aversion. One could also interpret the results of Parker et al. (2018)

in terms of loss aversion. They investigated the relationship between self-concept and sex differences in academic achievement in maths, literacy, and general academic domains in five age cohorts born between 1981 and 1993. In their literature review, they reported that "in relation to general academic self-concept … boys have higher self-concept than girls despite having lower achievement" (p. 128).

In their own investigation, Parker et al. stated that "we estimated the sex difference in residual self-concept [i.e. after controlling for achievement] and found that … boys' math self-concept was a tenth of a SD higher than girls despite performing objectively worse".

The link to loss aversion can be found in the related concept of self-esteem. While self-esteem and self-concept have different meanings, they are not independent. Self-concept is the individual's overall perception of themselves, while self-esteem is the individual's valuation of themselves. However, this valuation cannot be made without a self-concept. We can therefore say that self-esteem depends on self-concept, but how does self-esteem relate to risk aversion?

According to Josephs et al. (1992), individuals with low self-esteem "tended to choose the action that minimised a potential for threat, while the high [self-esteem] individuals, in contrast, were less averse to risk". They argued (p. 35) that even individuals with high self-esteem would protect their self-esteem by taking lower risk "when the value of a payoff becomes sufficiently important".

Overconfidence and Forecast Errors

Given a positive relationship between effort and grades, investing more time in studying is likely to reduce the risk of achieving a bad grade. Increasing effort can thus be viewed as risk-minimising behaviour.

Systematic sex differences in time spent studying could therefore be due to systematic sex differences in risk aversion, or more specifically, differences in loss aversion. This concept stems from the prospect theory of Kahneman and Tversky (1979) in relation to a risky monetary investment. In their words (p. 279), "A salient characteristic of attitudes to changes in welfare is that losses loom larger than gains. The aggravation that one experiences in losing a sum of money appears to be greater than the pleasure associated with gaining the same amount." In other words, loss aversion implies an asymmetric evaluation of losses and gains.

In the context of academic achievement, this implies that the pain of achieving one grade unit below a certain reference point outweighs the pleasure of achieving one grade unit above this point. Hence, it is reasonable to believe that more loss-averse persons would spend more time studying to avoid the "loss", i.e. a bad grade (or a grade worse than the reference point, which could be the ambition).

While Kahneman and Tversky's original work did not specifically address sex differences, subsequent studies have investigated this aspect. One study found that men tend to be more overconfident in their predictions compared to women, which can lead to greater forecast errors (Barber & Odean, 2001; Hofmann, 2022). This overconfidence in men often results in overestimating the likelihood of positive outcomes and underestimating negative ones. Women, on the other hand, tend to be more conservative in their predictions, which can sometimes lead to more accurate forecasts (Barber & Odean, 2001; Dawson, 2023).

Consistent with biological structures and their effects, research indicates that women are generally more risk-averse than men, which influences their forecasting behaviour (see e.g. Croson & Gneezy, 2009; Harris et al., 2006). This risk aversion can lead to underestimating the likelihood of positive events and overestimating negative events.

The study by Dunlosky and Rawson (2012), who explore the impact of overconfidence on students' learning outcomes, is particularly relevant in this context. The main findings are:

- *Monitoring Accuracy and Learning*: The study emphasises the importance of accurately monitoring one's own learning to enhance study effectiveness. Accurate self-evaluations help students control their study habits better, leading to improved learning and retention.
- *Experimental Studies*: Across two studies, the researchers examined both experimentally manipulated judgement accuracy and individual differences in accuracy. In both cases, greater accuracy in self-evaluations was associated with higher levels of retention.

- *Findings on Judgement Accuracy*: In both studies, students who had greater accuracy in judging their learning showed higher levels of retention. Overconfident students, who inaccurately judged their learning as sufficient, tended to underprepare and perform worse on subsequent tests. This underachievement was not due to differential feedback, effort during study, or trials to criterion but was directly linked to inaccurate self-assessments.
- *Implications for Interventions*: The results suggest that many students could benefit from interventions aimed at improving their ability to judge their own learning accurately. Enhancing this skill could lead to better academic performance and retention.

Thus, self-evaluation tests for males could improve realism, which in turn could impact on males' effort in theory tests.

No Sex Differences in Learning Abilities

Since females generally perform better on academic tests, it is of interest to assess whether sex differences in learning abilities exist. If so, this would weaken the risk aversion – increased effort argument. Research indicates that no such differences exist.

Hyde and Kling (2001) analysed 46 different meta-analyses with data including around 7 million people. These studies investigated sex differences in a wide variety of activities, ranging from language skills to throwing ability. In 78% of the studies, the sex differences were found to be small or negligible. The author concluded that, all in all, the results from the meta-studies generally supported the hypothesis of *sex similarities* in *learning abilities*: "men and women, as well as boys and girls, are more alike than they are different" (p. 581). When differences did exist, she found that "[g]ender differences can vary substantially in magnitude at different ages and depend on the context in which measurement occurs" (p. 581).

Spelke (2005) supported the sex similarity hypothesis of Hyde and Kling (2001). Spelke (2005, p. 950) claimed that research "provides evidence that mathematical and scientific reasoning develop from a set of biologically based cognitive capacities that males and females share. These capacities lead men and women to develop equal talent for mathematics and science".

This claim is supported by the finding in Delaney and Devereux (2021) that "… boys and girls typically have similar IQ scores and girls do not systematically score better in standardised tests such as SAT, ACT, and AP exams."

Overall, the bulk of the literature that we examined appears to favour *equality in learning abilities*.

Sex-Differentiated Learning Styles, Communication and Feedback

Learning Styles. Men and women may have distinct preferences in how they learn and process information. For example, studies indicate that women often excel in collaborative and communicative learning environments, while men may prefer hands-on, competitive approaches (Halpern, 2012).

Communication Styles. Effective communication is crucial in driving education. Women often prefer a more relational and supportive communication style, while men may favour direct and succinct instructions (Tannen, 1990).

Feedback Mechanisms. Feedback is essential for skill development. Research shows that women tend to respond better to positive reinforcement, while men often seek and benefit from challenge- and improvement-oriented feedback (Doldor et al., 2021; Flores-Torres et al., 2022).

Risk Aversion, Academic Effort and Performance

Studies consistently show that females exhibit higher levels of risk aversion compared to males (Sarin & Wieland, 2012). Reducing academic effort has similarities with gambling and participating in risky activities. Consistent with the facts that women perceive higher probabilities of negative outcomes and perceive the potential negative outcomes of risky behaviours as more severe, it is reasonable to believe that risk aversion is a significant factor influencing academic effort and performance.

According to Byrnes et al. (1999), "[g]oals and values determine the kinds of outcomes that are pursued by an individual (e.g. good grades in school vs. being popular with friends) and determine the kinds of options that are considered (e.g. studying vs. socialising). … In essence, then, risk taking involves the implementation of options that could lead to negative consequences."

In an educational context, this suggests that when preparing for an exam, more risk-averse female students will likely exert greater effort than their less risk-averse male counterparts.

Thus, females' higher risk aversion reasonably leads to more consistent and diligent study habits. They are more likely to allocate time effectively to avoid negative academic outcomes, such as poor grades. This behaviour aligns with the idea that individuals with high risk aversion invest more effort to prevent adverse results.

Since there is a positive relationship between effort and performance, the increased academic effort by females is likely to produce better academic performance.

Sex Differences in Driving Behaviour

Özkan and Lajunen (2006) investigate how sex (male and female) and sex roles (masculinity and femininity) influence driving behaviour and self-assessment of driving skills among young drivers. The research found that being male predicted a higher number of total, active and passive accidents, as well as better perceptual-motor skills. Masculinity was positively associated with perceptual-motor skills, while femininity was positively associated with safety skills. The study concludes that sex roles significantly impact driving behaviour, with masculine traits linked to riskier driving and feminine traits linked to safer driving practices.

In a study by Pan et al. (2023), the role of impulse control in mediating sex differences in driving speed management is explored. The results show that male drivers tend to drive faster than female drivers, particularly on simpler road sections. While no sex differences were found in impulsivity traits, male participants exhibited significantly lower levels of impulse control. The study reveals that impulse control partially mediates the relationship between sex and driving speed, suggesting that lower impulse control in men contributes to their higher driving speeds and associated risks.

In a study on sex differences in risk-taking driving behaviours among seniors aged 65 and older, Cordellieri et al. (2024) find evidence indicating that older male drivers continue to exhibit riskier driving behaviours compared to their female counterparts. The study highlights the need for targeted interventions to improve risk awareness among older men, as they are less likely to view responsible driving actions, such as observing speed limits, as desirable.

Granié et al. (2021) investigate the effect of cultural context on sex differences in driver risk behaviour across 32 countries. The study found significant sex differences in risky behaviours and attitudes, with men valuing crash-risk behaviours more than women in all cultural clusters observed.

The interactions between sex and culture were more pronounced in Western countries compared to the Global South. The findings suggest that both biological and social factors contribute to these sex differences, and cultural context plays a crucial role in shaping these behaviours.

Table 11.2

Summary of findings from driving behaviour studies

Study	Main Findings	Context
What causes the differences in driving between young men and women? The effects of sex roles and sex on young drivers' driving behavior and self-assessment of skills	Being male predicted a higher number of total, active, and passive accidents. Masculinity was positively associated with perceptual-motor skills, while femininity was positively associated with safety skills.	Investigates how sex and sex roles influence driving behavior and self-assessment of driving skills among young drivers.
Influences of fertility status on risky driving behaviour: how ovarian hormones affect risky behaviour in women drivers	Women are more risk-averse during their high-fertility phase. Higher levels of ovarian hormones are associated with increased caution and risk aversion.	Explores the impact of ovarian hormones on risky driving behavior in women.
On the road safety: sex differences in risk-taking driving behaviors among seniors aged 65 and older	Older male drivers exhibit riskier driving behaviors compared to older female drivers. Older men are less likely to view responsible driving actions as desirable.	Examines sex differences in risk-taking driving behaviors among seniors aged 65 and older.
The effect of culture on sex differences in driver risk behavior through comparative analysis of 32 countries	Significant sex differences in risky behaviors and attitudes, with men valuing crash-risk behaviors more than women. Cultural context plays a crucial role in shaping these behaviors.	Analyzes the effect of cultural context on sex differences in driver risk behavior across 32 countries.
Sex difference in driving speed management: the mediation effect of impulse control	Male drivers tend to drive faster than female drivers, particularly on simpler road sections. Lower impulse control in men contributes to their higher driving speeds and associated risks.	Investigates the role of impulse control in mediating sex differences in driving speed management.

Tailored Educational Strategies for Driving School Programmes

Understanding sex differences in brain structure, hormonal influences, and risk aversion provides valuable insights for developing tailored educational strategies. Recognising that females may benefit from environments that support their diligent study habits and risk-averse nature, while males may thrive in settings that encourage exploratory learning and manage risk-taking behaviours, can help create more inclusive and effective learning environments. By addressing these differences, educators can better support the academic success of all students, ensuring that both males and females can leverage their unique strengths and overcome their challenges.

The Goals for Driver Education (GDE) matrix (Hatakka et al., 2002) serves as a comprehensive framework aimed at enhancing driver education by addressing various levels of driver behaviour and decision-making. Its implementation within driving schools has the potential to significantly elevate the quality of driver training, particularly when integrated into a stepwise training approach.

In the context of Norwegian driver training, the GDE matrix (Hatakka et al., 2002) functions as the theoretical foundation for all traffic training programmes. The insights provided by the article concerning sex differences should be more extensively incorporated into the curricula for driver training.

These sex differences should be particularly emphasised at two stages of the stepwise training process.

At Level 1 of the GDE matrix (Hatakka et al., 2002), the focus is on acquiring fundamental skills, including basic vehicle control and understanding traffic regulations. At this stage, the GDE matrix can be utilised to promote self-awareness and reflection among learner drivers, with a specific emphasis on sex differences.

By integrating elements of the GDE matrix, driving teachers can encourage learner drivers to reflect on their personal attitudes, motivations, and behaviours in relation to driving. For instance, learners can be prompted to consider how their emotional state, stress levels, and risk perception influence their driving performance. This reflective practice not only enhances their understanding of basic driving skills but also lays the groundwork for more advanced competencies.

Level 4 of driver training involves the development of higher-order skills, such as hazard perception, risk management, and decision-making in complex traffic situations. The GDE matrix is particularly pertinent at this stage, as it addresses the broader context of driving, including social and environmental factors. Driving teachers should consider sex differences in their training programmes, thereby better tailoring the training to individual needs.

Driving teachers can integrate the GDE matrix by guiding learners through scenarios that require critical thinking and problem-solving. This process encourages learners to reflect on their own driving behaviour and consider how they can contribute to safer road environments.

Emotional Regulation and Stress Management

- **For Females**: Include training on stress management techniques, such as deep breathing exercises and mindfulness, to help manage anxiety during driving. Create a supportive learning environment where students feel comfortable expressing concerns.
- **For Males**: Teach techniques for controlling impulsive reactions and managing frustration. Use role-playing scenarios to practise staying calm in stressful situations, such as heavy traffic or aggressive drivers.

Driving Skills of Females

- **Confidence-Building Exercises**: Driving schools should emphasise exercises that build confidence in their driving abilities. This can involve positive reinforcement and gradual exposure to more challenging driving scenarios (Continuous Improvement in Education, 2021).
- Given their higher risk aversion, incorporate modules that build confidence in handling unexpected driving situations. Use simulations to practise emergency manoeuvres in a controlled environment, helping to reduce anxiety and improve decision-making under pressure.

Addressing Overconfidence in Male Learners

- **Enhanced Risk Awareness Training**: Given that men tend to be more overconfident, driving schools should incorporate modules that emphasise the dangers of overconfidence. This can include real-life case studies of accidents caused by overestimating driving abilities and underestimating risks. Incorporating assessments that challenge students' perceptions of their driving abilities can be effective. Simulation tools can be utilised to demonstrate the consequences of risky behaviours, allowing male students to experience the potential outcomes of their decisions in a safe environment.

- **Pass rates of theory** exams: Make men aware that it generally pays off to spend more time on the theoretical part of the driving school programme. This will usually result in them spending less time obtaining their driver's licence.
- Incorporate more interactive and hands-on learning experiences. Use gamification techniques to make learning engaging and competitive. Offer challenges that require quick thinking and adaptability.
- **Frequent Reality Checks**: Implement regular assessments and feedback sessions to provide male learners with a realistic understanding of their driving skills. Use objective metrics to highlight areas needing improvement. In this respect, interventions aimed at improving their ability to judge their own learning accurately could lead to better academic performance and retention.
- **Simulation of High-Risk Scenarios**: Use driving simulators to expose male learners to high-risk situations in a controlled environment. This can help them understand the potential consequences of overconfident driving behaviours.
- **Personalised Feedback**: Provide sex-specific feedback that addresses the unique tendencies of male learners. Focus on tempering overconfidence with constructive criticism. Instructors can focus on the importance of responsibility and accountability in driving. By fostering discussions around the consequences of overconfidence, schools can encourage male students to recognise the limits of their skills and the importance of adhering to safety practices.

Structured peer feedback sessions can create opportunities for students to reflect on their driving experiences. By hearing from classmates about their perceptions of risks and abilities, male students may gain a more balanced understanding of their driving skills.

Both the Traffic Education Regulations (Lovdata, 2025) and the curriculum for driver training (NPRA, 2018) should incorporate this knowledge. Ensuring that learner drivers comprehend both the opportunities and challenges posed by sex differences will positively impact traffic safety.

Discussion and Concluding Remarks

The present research highlights the significant role that both brain structures and hormones play in contributing to sex differences in risk-taking behaviour. Specifically, oestrogen has been shown to contribute to higher risk aversion and more careful driving among females, whereas testosterone tends to have the opposite effect, promoting riskier driving behaviours among males. These biological differences extend beyond driving behaviours and also influence academic efforts, with females generally spending more time studying to avoid poor exam results. In the context of driving education, females appear to be more structured and to put in greater effort compared to males.

Integrating these research findings into driving education can lead to the development of more effective and inclusive learning environments. By tailoring educational strategies to address overconfidence and forecast errors in conjunction with risk aversion, driving school programmes can better cater to the unique challenges and strengths of both male and female learners. This approach not only promotes safer driving behaviours but also enhances overall driving competence. The following aspects are highlighted:

Risk Willingness: The tendency for men to be more willing to take risks than women can be addressed at Level 4 of the Goals for Driver Education (GDE) matrix, which focuses on attitudes and risk understanding. Training modules that highlight the dangers of overconfidence and risky behaviour, particularly targeted at male students, can be effective. These modules should emphasise the potential consequences of risky driving and encourage a more cautious approach. For women, driving teachers can focus on building confidence and decision-making skills to balance their natural risk aversion.

Learning Styles: Recognising that women may benefit from more structured and collaborative learning environments, while men may thrive with practical methods, appears to be important. This can be implemented at Levels 1 and 2 of the GDE matrix by adapting teaching methods to suit different learning styles. For example, incorporating group discussions and collaborative projects for female learners, and hands-on driving experiences and simulations for male learners, can enhance the effectiveness of the training.

Feedback and Assessment: Frequent reality checks and personal feedback are essential for helping male students gain a more realistic understanding of their skills and areas for improvement. This can be integrated at all levels of the GDE matrix, ensuring that feedback is continuous and constructive. Personalised feedback sessions can help male learners recognise their limitations and work towards improving their driving behaviour, ultimately leading to safer driving practices.

Tailored Instruction: Recognise that male and female learners may have different strengths. For example, men might excel in spatial tasks, while women might perform better in tasks requiring verbal memory and multitasking. Driving instructors can use this knowledge to tailor their teaching methods, such as using more visual aids for men and more verbal instructions for women.

These examples illustrate how understanding and addressing sex differences in brain structure and hormonal influences can lead to more effective and inclusive educational practices. By recognising and addressing sex differences in brain structure, hormonal influences, and the consequential risk aversion differences, driving school programmes can create more effective and inclusive learning environments. These tailored strategies can help both male and female students develop the skills and confidence needed to become safe and competent drivers.

As a topic for future research, we advocate looking into sex-adapted driving simulators addressing stereotypical sex-dependent behaviour in stressful situations.

Ethical considerations of sex-segregated education in traffic training include the potential reinforcement of sex stereotypes and inequality. Tailoring instruction based on sex may perpetuate biases, limiting opportunities for both boys and girls. It is crucial to ensure that such practices do not undermine the principles of equality and inclusivity in educational settings. This is something the traffic teacher must consider to ensure that sex stereotypes do not become overly prominent.

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