Enforcement as part of an integrated approach to road safety

European Road Safety Summer School
Mechelen, Belgium
August 31st 2017
Enforcement?

- What is traffic enforcement?
- Why traffic enforcement?
- Is there any theory behind?
- It is useful?
- Challenges & considerations
- Conclusive remarks
1. The enforcement system
What is traffic enforcement?

- Enforcement =
  
  “the act of compelling observance of or compliance with a law, rule or obligation.”
  
  (Oxford Dictionaries)

- Traffic enforcement consists of:
  - Legislation
  - Enforcement of the law
  - Judicial system
Legislation

- Objectives (e.g. highway code):
  - Efficiency
  - Safety

- Effect legislation on road safety:
  - Favourable effects reported, e.g., legal BAC 0.1% to 0.08% US (Wagenaar et al.); speed limit 90 to 70 kph (De Pauw et al.), ...

- Considerations
  - Legislation that prescribes human behaviour can only improve safety if it changes the targeted behaviour
  - Governments/parliaments tend to be faster in changing legislation than in creating budgets for proper communication, enforcement or other measures
  - Social norms influence legislation (democratic process), but in the longer run legislation can also influence social norms (e.g., BAC-limit)
Enforcement (in the strict sense)

- Enforcement = “police enforcement”
- Primary or secondary enforcement
- Typical: speed, alcohol, safety restraints (seat belt, helmet wearing)
- Others:
  - Moving: violations regarding overtaking, priority giving, driving time & rest periods, ...
  - Non-moving: violations regarding parking, technical equipment, onboard documents, driving licence, ...
Judicial system

- Prosecution & punishment

- Judicial perspective ↔ public health perspective

  - Courts:
    - Own set of rules (limits of law including procedures, power of evidence)
    - Case by case
    - Taking into account background, history, circumstances

  - Public health:
    - Punishments should discourage unwanted behaviour
Merel De Prins ...
2. Why traffic enforcement?
Why traffic enforcement?

Crashes involve:

- Humans
- Vehicles
- Roads
Why traffic enforcement?

Figure 13-3 Percent contributions to traffic crashes estimated in British and US in-depth studies. Based on Ref. 6.

Source: Evans, 2004
Why traffic enforcement?

- Road environment: 2-3%
- Road env. & Road user: 0.3%-1.8%
- All Three: 0.3%-1.8%
- Vehicle: 2-3%
- Road user & Vehicle: 2-6%
- Road user: 65%-77%

Source: Sabey and Taylor (1980), Carsten et al. (1989)
Why traffic enforcement?

- Dominant role of driver behaviour in crashes

- More in-depth research (Wundersitz et al., 2014):
  - Driver behaviour contributes to crashes via:
    - Mechanism 1: (unintended/unconscious) failure to comply with rules
    - Mechanism 2: (intended/conscious) illegal & extreme behaviour


<table>
<thead>
<tr>
<th>Crash causation category</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>System failure</td>
<td>58</td>
<td>30.7</td>
</tr>
<tr>
<td>Illegal system failure</td>
<td>45</td>
<td>23.8</td>
</tr>
<tr>
<td>Extreme behaviour</td>
<td>86</td>
<td>45.5</td>
</tr>
<tr>
<td>Total</td>
<td>189</td>
<td>100.0</td>
</tr>
</tbody>
</table>
3. Theoretical bases for enforcement
What would be a fair punishment for a car driver who hits a child while speeding?

What would prevent this driver from speeding?
Theoretical bases

- Deterrence Theory
- Rational Choice Theory
- Learning Theory
Deterrence Theory
Deterrence theory

- Background:
  - International political sciences & criminology
Deterrence Theory

- Basic premises:
  - Use of punishment as a threat to deter people from offending
  - Specific punishments imposed on offenders will ‘deter’ or prevent them from committing further crimes
  - Fear of punishment will prevent others from committing similar crimes
Deterrence theory

- **Key-principles:**
  - **Severity**
    - Proportionality:
      - Punishment that is not severe enough will not deter
      - Punishment that is too severe is unjust

  \[ \Rightarrow \text{Severity of the punishment } \sim \text{ seriousness of the crime} \]

  - **Certainty**
    - Probability of apprehension & punishment for a crime
      (e.g., “there is a 1% chance I will get caught, and if so, they would never throw me in jail”)

  - **Celerity**
    - Swiftness with which criminal sanctions are applied after the commission of crime
Deterrence theory

- Sanction severity
- Apprehension certainty
- Sanction celerity
- Fear punishment
- Crime deterrence
- Rule compliance
- Legitimacy punishment
Deterrence theory

- Perceived legitimacy:
  - Distributive justice
    - “the justice that is concerned with the apportionment of privileges, duties, and goods in consonance with the merits of the individual and in the best interest of society” (Merriam-Webster)
    => For all those who do not comply with traffic rules, the probability of getting punished should be equal.
  - Procedural justice
    - “the idea of fairness in the processes that resolve disputes and allocate resources”
    => All those who do not comply with traffic rules should be treated equally
Deterrence theory

- 2 sorts of deterrence: general and specific

  - General deterrence: impact of the threat of legal punishment on the public at large
    - Results from the perception of the public that traffic laws are enforced and that there is a risk of detection and punishment when traffic laws are violated
      - Example: (announcement of) alcohol checks next weekend

  - Specific deterrence: impact of the actual legal punishment on those who are apprehended
    - Results from actual experiences with detection, prosecution and punishment of offenders
      - Example: license suspension for speeding recidivist
Rational Choice Theory
Rational choice theory

- Background: economic philosophy
Rational choice theory

- Human behaviour is ...
  - ... goal-oriented (e.g., happiness)
  - ... dependent upon means and constraints
  - ... focused on “highest utility”
    => Maximum benefit at minimum cost
  - ... based on rational balance of means & constraints
Rational choice theory

- Benefits can be both material & immaterial
  - Safety, comfort, speed, status, pleasure, sensation, ...

- Costs:
  - Material costs
    - fuel cost, cost of equipment
  - Psychological costs
    - disagreement of peers, violation of personal norms
  - Opportunity costs
    - Time that could be spent doing something else
  - Expected punishment costs
    - Main focus of deterrence theorists
Rational choice theory

- Are humans partial or fully (ir)rational?

  - Pure rational choice models work well for mathematical models, but ...

  - ... humans often make choices that are only partially rational ...

  - ... or even (predictably) irrational...
Rational choice theory

Cognitive biases of decision-making and belief

- Anchoring – overreliance on one piece of information when making decisions
- Bandwagon effect – tendency to interpret information/situations according to others’ decisions and behaviours
- Confirmation bias – misinterpret information through existing assumptions
- Endowment effect – valuing the same asset differently owing to it being owned or not
- Framing effect – interpretation of the same information differently due to presentation and context
- Hyperbolic discounting – preference for immediate rather than later pay-offs
- Loss aversion – tendency to value losses more heavily than gains
- Planning fallacy – underestimation of time taken to complete tasks/projects
- Availability heuristic – interpret according to examples in recent memory
- Optimism bias – tendency to be over-optimistic regarding forecasts
- Overconfidence effect – tendency to misinterpret realities owing to the overestimation of personal abilities
Learning Theory
Learning theory

- Background: psychology (behaviorism)
Learning theory

- Basic premises:
  - Behaviour is shaped by antecedents and consequences
    - antecedents: conditions that occur before the behaviour of interest
      - ‘stimulus’ (a flashing light, a bell tone)
    - consequences: conditions occurring after the behaviour that increase or decrease the probability of the behaviour occurring again
      - ‘reinforcement’ (positive: food vs. negative: electric shock)
  - Learning = process where an antecedent triggers (or inhibits) a specific behaviour in function of the expectancy that a specific consequence will follow
Learning theory: antecedents

<table>
<thead>
<tr>
<th>Antecedent</th>
<th>Description</th>
<th>Traffic Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occasion</td>
<td>Signals to individual that reinforceable behavior is appropriate, or signals that a behavior if performed will be punished (an inhibitor)</td>
<td>A red stop light: Signals the driver to stop, or possible punishment will occur</td>
</tr>
<tr>
<td>Rule</td>
<td>A law that is passed; a social norm that has evolved in the culture</td>
<td>Primary safety belt law</td>
</tr>
<tr>
<td>Models</td>
<td>Individuals witness others receiving consequences for behavior</td>
<td>Witnessing an officer pull another driver over for speeding; having a friend who received a ticket from automated enforcement</td>
</tr>
<tr>
<td>Structural antecedent</td>
<td>Relatively permanent stimuli, from the person (personality characteristics or environment (infrastructure))</td>
<td>A driver’s mental health or affect affects driving (e.g., see Chapter 13 of this handbook); narrower roads slow speeds (e.g., traffic calming)</td>
</tr>
<tr>
<td>Establishing operations/</td>
<td>Situation that affects consequence sensitivity; affects motivation</td>
<td>Fatigue creating likelihood of running red light</td>
</tr>
<tr>
<td>motivating condition</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Antecedents from Mattaini (1996).*
Learning theory: consequences

- Two consequences affecting behaviour are:

  - **Rewards** (‘positive reinforcement’):
    - Any consequence that ‘strengthens’ a behaviour
      - Positive reward = adding something good
      - Negative reward = removing something bad

  - **Punishments** (‘negative reinforcement’):
    - Any consequence that ‘weakens’ a behaviour
      - Positive punishment = adding something bad
      - Negative punishment = removing something good
Learning theory: consequences

THE 4 QUADRANTS OF OPERANT CONDITIONING

When training an animal, there is one behavior that we want to reinforce (increase), and another behavior that we want to punish (decrease). We can add something good or bad (+ positive) or remove/delay something good or bad (- negative) to get the behavior we want.

IN THIS EXAMPLE: the behavior we want to reinforce is LOOSE-LEASH WALKING. The behavior we want to punish is PULLING ON THE LEASH.

+R

POSITIVE REINFORCEMENT
ADDING GOOD STUFF TO INCREASE A BEHAVIOR

YES!
LIKE!

More loose-leash walking! Give treats, keep walking forward when leash is loose.

-P

NEGATIVE PUNISHMENT
DELAYING GOOD STUFF TO DECREASE A BEHAVIOR

No more pulling! Stop walking & no treats, until leash is loose.

-R

NEGATIVE REINFORCEMENT
DELAYING BAD STUFF TO INCREASE A BEHAVIOR

I BETTER WATCH OUT.

More loose leash walking! Delay leash pop & scolding until he pulls again.

+P

POSITIVE PUNISHMENT
ADDING BAD STUFF TO DECREASE A BEHAVIOR

NO!
LIKE!

No more pulling! Give leash correction and scolding when he pulls.

Illustration inspired by “Clickertraining 101” / ClickerExpo 2011

Lili
## Learning theory: consequences

### TABLE 31.2 Daniels and Daniels’ (2004) Codes for the Four Consequences with Specific Traffic Examples

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Traffic Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>R+</td>
<td>Positive reinforcement (e.g., giving something desirable; increases behavior)</td>
<td>Feeling pleasure when speeding and speeding more in the future</td>
</tr>
<tr>
<td>R−</td>
<td>Negative reinforcement (e.g., taking away something undesirable; increases behavior)</td>
<td>Slowing down to avoid a speeding ticket when witnessing police on the road and being more likely to act similarly in the future</td>
</tr>
<tr>
<td>P+</td>
<td>Positive punishment (e.g., giving something undesirable; decreases behavior)</td>
<td>Receiving a ticket for red light running and being less likely to run a red light in the future</td>
</tr>
<tr>
<td>P−</td>
<td>Negative punishment (e.g., taking away something desirable; decreases behavior)</td>
<td>Losing a vehicle when it is impounded after an impaired driving arrest and being less likely to drink and drive in the future</td>
</tr>
</tbody>
</table>

Source: Porter, 2011
4. Effects of enforcement
Effects of enforcement

Effects of enforcement:
- Effects on behaviour (direct)
- Effects on number of crashes (indirect)

A (very) brief summary of empirical effects of enforcement (Elvik et al., 2009):
- Safety belt use:
  + 20% (depending on the initial level)
  -40% fatal risk in case of crash
- DUI:
  -9% injury crashes
- Speeding:
  Automated enforcement: -16% injury crashes
  Police patrols: no effects found
Effects of enforcement

- Generally favourable effects
- (partially) adverse effects possible!
  - Cf. Red Light Cameras (next slide)

=>$>\text{ Proper assessment is required!}$
Effects of enforcement: RLC

Red Light Camera’s

Effects on crashes (Høye, 2013; De Pauw et al., 2014)

<table>
<thead>
<tr>
<th></th>
<th>All types of crashes</th>
<th>Side crashes</th>
<th>Rear-end crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury + PDO* crashes</td>
<td>+6% (^1)</td>
<td>-13%(^1)</td>
<td>+39%(^1)</td>
</tr>
<tr>
<td>* = property damage only</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injury crashes</td>
<td>-13%(^1)</td>
<td>-33%(^1)</td>
<td>+19%(^1)</td>
</tr>
<tr>
<td></td>
<td>+5%(^2)</td>
<td>-6%(^2)</td>
<td>+44%(^2)</td>
</tr>
<tr>
<td>Severe injury crashes</td>
<td>-14%(^2)</td>
<td>-24%(^2)</td>
<td>-</td>
</tr>
</tbody>
</table>

5. Challenges
Problems with traditional enforcement

2 basic problems with traditional enforcement:

- Difficult to achieve high detection probabilities
  - Abundance of trips, movements & possible violations
  - Cost of personnel & equipment

  ⇒ Deterrence theory: perceived certainty of sanction is biased!
  ⇒ Rational theory: perceived cost of unsafe actions is biased!
  ⇒ Learning theory: negative reward that strengthens unsafe actions!

- Lack of public support:
  - Widespread perception that traffic enforcement is used to raise government revenue

  ⇒ Deterrence theory: perceived legitimacy is questioned!
  ⇒ Rational theory: perceived benefit is questioned!
  ⇒ Learning theory: reinforcement effect is questioned!
## Alcohol detection probabilities

How often during the past 12 months have you been subjected by the police to a breath test?

<table>
<thead>
<tr>
<th></th>
<th>Attitude measurement 2006</th>
<th>Attitude measurement 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>92.49%</td>
<td>88.19%</td>
</tr>
<tr>
<td>Once</td>
<td>6.19%</td>
<td>8.91%</td>
</tr>
<tr>
<td>Multiple times</td>
<td>1.32%</td>
<td>2.90%</td>
</tr>
</tbody>
</table>

Source: attitude measurements BRSI
Automated enforcement

- Increasing number of applications:
  - speed checking
  - red-light-running
  - license plate recognition

- Advantages:
  - Objective
  - High probability of detection => increased ‘fairness’ (getting a fine is result of personal behaviour rather than ‘bad luck’)

- Limitations:
  - Public acceptance
  - No automated enforcement possible yet for many types of violations
Further considerations

- Enforcement tends to work better when combined with other measures such as awareness raising campaigns.

- Effects of enforcement might be rather short term:
  - it can change local & temporal behaviour, but does it change underlying attitudes?

- What works best? Increased detection rates or more severe punishments?
  - Frequency, visibility and unpredictability of inspections tend to be far more important than height of fines.
6. Conclusive remarks
Conclusive remarks

- Important for success of enforcement
  - Understanding of human behaviour
    - How & why does it (not) work?
  - ‘Measuring is knowing’ -> gather empirical evidence
    - Where, when does it (not) work?
  - Holistic policy approach towards road safety
Integrated Approach

Combined Actions

Structural and organisational influence

Legal influence

Technical influence

Individual influence

Social influence

Unsafe acts

Evolution of a latent failure

Road infrastructure and road environment contributing conditions

Legal framework, licensing and enforcement contributing conditions

Vehicle contributing conditions

Road user contributing conditions

Other road user contributing conditions

Errors Violations

Training issues on human factors

Accident

Road Safety Communication Campaigns (media only or with supportive activities) addressing behaviour changes
Improvement of road safety

- General & specific deterrence
  - Subjective detection probability
  - Objective detection probability
  - Enforcement activities

- Legislation
- Police resources

External factors
- Road infrastructure
- Vehicle technology
- Behaviour road users
- Driver education
- ...

Cooperation judicial system
- Cooperation responsible policy makers
- Communication with civilians

Source: Goldenbeld et al. (1999)
Thank you!

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