The Role of Implicit Data Collection Techniques in Driver Behaviour Research

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Abstract
This paper reviews the literature on implicit research methods, examining their existing and potential applications in transport research, and in particular predicting speeding behaviour. Current research methods in measuring attitudes to predict speeding behaviour include the use of questionnaires, interviews and focus groups. These methods attempt to explicitly extract self-reported awareness and introspection about their attitude. However, it has been well documented in the literature that self-report methodology has many shortcomings. The use of implicit methods (computer-based reaction time tests) on the other hand appears to avoid many of these issues by measuring attitude-related responses more objectively: by drawing on unconscious aspects of cognitive processing. This paper identifies the attractive features of implicit methods, how they address the majority of the shortcomings of self-report methodologies, and the level of their use in transport-related research. Their future potential is exemplified through the presentation of a methodological strategy to understand attitudes and behaviour with respect to speed management. The paper concludes that the application of implicit methods in transport-related research is still in its infancy, but there is a strong case for wider application in areas such as studies of travel behaviour change.

1. Introduction

In 2009-2010, the estimated economic cost of Road Traffic Accidents (RTAs) in the UK was around €17.4 billion (IRTAD, 2012). In addition, around six people die every day on UK roads (HM Government, 2013). Globally, the World Health Organisation (WHO) ranked RTAs as the ninth leading cause of death in 2004 and predicts it will become the fifth most important by 2030 (WHO, 2009 In the UK, the largest contributory factors in reported RTAs have been identified as speeding and human error (such as sudden braking), being key explanations in more than 65% of RTAs (DfT, 2011).

The conclusions from several lines of research appear to suggest that risky driving, such as driving at excessive speed, can be caused by numerous factors, such as peer influence (Fleiter et al., 2006), peer pressure (Horvath et al., 2012), over-confidence or the self-enhancing bias (Blincoe, Jones, Sauerzapf & Haynes ,2006), time urgency (Gulian et al., 1989; Musselwhite, 2006), sensation seeking (Jonah, 1997), anger (Deffenbacher et al., 1994; Lajunen, T. & Parker, D., 2001), stress (Musselwhite, 2006), authority rebellion (Fernandes et al., 2010), and a lack of conscientiousness (Arthur & Graziano, 1996; Arthur & Doverspike, 2001). The common feature of most of these factors is that they are themselves the result of underlying attitudes that the driver can hold. These attitudes can influence his or her actions in various ways and at particular moments when behind the wheel.

However, all this research has been based on explicit data collection methods, whereby drivers are asked to reflect on their behaviour and attitudes through questionnaires. The use of explicit methods assumes that drivers can and will report accurately and honestly about their own attitudes and driving behaviours. There are growing concerns that such methods invite a range of biases in the data, which questions their validity. The purpose of this review is to critically examine these methodologies and to discuss the suitability of alternative methods, in particular implicit reaction-time tests. These tests have several advantages over explicit methodologies, making them suitable for examining attitudes in order to better predict speeding behaviour and other risky driving behaviour.

2. Explicit measures

Accessing attitudes, behavioural intentions, and even behaviour itself using self-report (e.g., questionnaires, surveys, and interviews) has been the dominant method in studies attempting to understand driving behaviour. Self-report is good for measuring conscious attitudes (such as one's overall attitude towards speed cameras) and self-knowledge that is easy to introspect on (such as the frequency of driving specific routes). Self-report is not so good where the content is of an overly personal or sensitive nature (such as health-related issues or personal lifestyle issues), where there is a discussion of illegal behaviour (such as breaking speed limits, driving under the influence of illegal drugs, attempting to text whilst driving), and where the attitudes and the behaviour are socially unacceptable (e.g., aggressive driving). One reason for relying on self-report or explicit methods is that they can be relatively easy to develop, easy to implement, and less expensive or time-intensive compared to other objective methods. However, it has been documented in social psychological research as well as driver research, that self-reported information has many shortcomings, including forgetting; dishonesty; limitations in self-awareness and introspection; misinterpreting the question; demand bias; social desirability bias; evasive answer bias; and common method variance (af Wåhlberg, 2009).

Examples of studies demonstrating dishonesty or hiding or forgetting are the study of Wallén Warner and Åberg 2008) and Corbett (2001). The Åberg and Wallén Warner study found self-reported speeding to be about twice-as-strongly associated with other self-reported driving behaviour than with logged speeds. The Corbett study found low correlations between self-reported speed measures and speeds measured by speed cameras on the same road. These studies show that self-reported behaviour and more objectively measured behaviour do not always correlate. One possible reason is that attitude accessibility requires a greater amount of thought (Cacioppo et al., 1986) and as a result individuals may not be honest in reporting their behaviour or may not want to disclose past behaviour. This being the case, explicit measure can be easy to fake. However, a study carried out by Vianello et al. (2010) to measure conscientiousness using explicit and implicit methods demonstrates some of the benefits of the implicit approach. College students were given explicit and implicit measures of conscientiousness. Half were further told to imagine that they were being tested for their ideal job (good income, low effort) and half were not. Those given the job narrative had higher explicit measures of conscientiousness (showing that they could give biased answers), but both groups scored about the same on the implicit measure – which shows that the implicit measure was not easy to fake and respondents could deliberately distort the measure.

To acquire accurate responses using self-report can be very challenging because introspection is often poor. Nisbett and Wilson (1977) give the example of responding to the question "What is your mother's maiden name?" If someone knows the answer to the question they just say it, but they may not know how they knew – the name just came into their head. So, the depth at which introspection can occur is limited. In driver research, answering a question such as "How often do you rush through an amber light?" accurately would require a deep and clear access into one's memory system and it is likely that people construct answers to these kinds of questions based on what appears plausible. Therefore, it has been argued that introspection is often a constructive process, whereby people try to make sense of their own behaviours using any information at hand other than through accurate self-knowledge (Nisbett & Wilson, 1977). There is little research on this issue in driver behaviour specifically, but a study by Eby et al. (2003) of 99 licensed drivers aged 65 and above showed that they did not have good awareness of their own behaviour initially (implying a poor ability to introspect). However, the regular use of a diary-like workbook showed an increase in self-awareness of their driving behaviour. Similarly, Musselwhite and Haddad (2010) found group work focussing on driver behaviour improved self-awareness amongst older people. This implies that self-awareness is limited and there are strategies that can be used to increase it, but ordinarily, people do not use such strategies.

Another challenging issue for self-report measures is the misinterpretation of the question, particularly the level of comprehensibility. Lenzer et al. (2010) identified that there are seven psycholinguistic text features that can cause problems with comprehension: low-frequency words, vague or imprecise relative terms, vague or ambiguous noun phrases, complex syntax,

complex logical structures, low syntactic redundancy, and bridging inferences. These authors carried out an online experiment (n=825) to demonstrate that survey questions which use some of the problematic psycholinguistic text features could be misinterpreted due to lack of comprehension and can result in an unreliable measure.

A further problem with self-report is "evasive answer bias" (avoiding an answer or deliberately replying with an incorrect answer). For example, a participant only interested in a financial incentive offered to take part in a survey may rush through a set of questions without even reading them properly. Detecting instances of this bias can be maximised using a randomisation of the question order or a randomisation of the possible answers, so that some questions are reversed. For example, in a scale on attitudes to speeding that requires Yes and No answers, questions can be worded such that sometimes the Yes response indicates a positive attitude (e.g. "Do you get pleasure from accelerating quickly?") and sometimes the No response indicates a positive attitude (e.g., "Do you often leave a large distance between you and the vehicle in front?"). Although Warner (1965) found that this method may not completely eliminate the problem, and therefore there is no guarantee of the reliability of the survey.

Another issue with self-report is the possibility of the occurrence of demand artifacts (where the respondent anticipates or tries to work out what the researcher is trying to achieve and answers accordingly). In consumer research, the occurrence of demand artifacts was demonstrated by the experiment carried out by Han et al. (1994): while attitudes and purchase intentions towards specific products were well correlated across survey mode (personal interview, telephone interview, and self-report survey), the demand artifacts were particularly vulnerable in personal interviews.

Driving above the speed limit on the public highway is a legal offence and can be expected to be considered socially undesirable behaviour by the majority of citizens. Lajunen and Summala (2003) carried out a series of studies investigating the occurrence of social desirability bias in response to a number of driving inventories or questionnaires and concluded that social desirability tends to exist especially in studies carried out in a public setting (presence of researcher or observer).

Another problem with explicit questionnaires and surveys is that when the same method is used to collect data relating to two variables from the same participants, any observed relationship between them might be spurious. This is known as common method variance (CMV). For example, significant correlations can occur between two measures if a participant displays social desirability on both measures (after all, if they show it on one measure then they are likely to show it on another measure). The same might apply to biases in question wording, or in lengthy scales where the respondent is in a hurry to complete the scale. It has been estimated that between 25% and 40% of the variance in social science studies can be due to CMV (Cote and Buckley, 1987).

Given all of these problematic features of explicit measures, af Wåhlberg (2009), in his review of self-report studies in driver psychology, concludes that:

> In general, we therefore need to start all over again in several areas, notably regarding driver aggression, where not a single study using objective data has been found…Overall, the recommendation is therefore to abstain from using self-reports, as they are simply not reliable, if there is any alternative available (p.63).

Although most forms of data collection have some form of limitation, this clearly shows that there is a demand for using alternative methods to avoid or minimise the shortcomings of self-report measures, in particular when they are used to measure transport-related attitudes. Since driver attitudes are thought to be key predictors or risky driving, we shall focus our attention on the subject of attitudes and how they can be assessed.

3. Implicit attitudes

An important predictor of behaviour is the attitudes that underlie it, especially a positive attitude towards the behaviour (Ajzen, 1991). A positive attitude towards speeding is an evaluative judgement that speeding is good. It has been suggested that an attitude can exist

consciously or unconsciously and so some attitudes can be expressed verbally (explicitly) but others cannot, yet still influence behaviour (Fazio & Zanna, 1978). In this view, behaviour can be driven by conscious as well as unconscious processes and so the existence of dual processing systems is assumed, in which conscious and unconscious processes influence behaviour in a number of possible ways, independently, together, or through a more complex interaction.

Attitudes are based on individual's direct experiences and individual's observations from the external environment (other drivers, media, parents, friends and family). The more experience or exposure we have with something, the more we may come to like it; this is known as the "mere exposure effect" (Zajonc, 1968) and implies that, in the case of speeding, the more a driver speeds and experiences the pleasure of driving at a fast speed, the more that attitude will be strongly ingrained into the person's memory.

Determining that unconscious influences have an important cognitive role to play presupposes the existence of dual processes. Dual process theory has been around since the 1980s and is the view that there are two main cognitive systems, one is unconscious and involves automated, habitual, and rapid processes, and the other is a conscious one that involves controlled, deliberate, slow processes. Interest in the unconscious has never been greater: one reason may be increasing evidence that unconscious processes "influence perception, judgements, feelings, and behaviour" (Wilson, 2002). There are numerous demonstrations of the influence of unconscious processing, an example of how unconscious perception can influence conscious decision making is from Deeprose et al. (2004) who demonstrated learning during anaesthesia. The word 'tractor' was played to patients during surgery under general anaesthetic. Afterwards, they were given unfinished word stems (such as TRA___) to complete with the first word that came into mind. They found that previously having played the word increased the likelihood it would be used to complete the stem. This shows that the words could not have been processed explicitly or consciously yet they later influenced decisions in a linguistic task.

In a recent meta-analysis on the relationship between attitudes and behaviour, Glasman and Albarracin (2006) conclude that the relationship is strong when the underlying attitudes are stable and deep-seated. According to Fazio (1990), encountering objects associated with a strong attitude can activate that attitude spontaneously and so directly influence behaviour. Furthermore, attitudes can influence behaviour automatically without effortful processing and reflection or even awareness that the attitude has been activated. This being the case, attitudes measured implicitly might be good predictors of behaviour. Implicit measures therefore may provide a number of attractive features that explicit methods do not have (Dimofte, 2010). This means that in many cases implicit methods can be used to complement explicit methods, and in some cases could be used in their place

The main advantages of implicit methods appear to be (a) avoidance of demand effects as they are difficult to fake – it is thus possible to tap attitudes that respondents are trying to hide or those they are trying to portray to appear socially desirable or to appear to be consistent (Oskamp & Schultz, 2005), (b) avoidance of a reliance on the accuracy of introspection, because they do not rely on a verbal response or accurate self-knowledge (Fazio & Olson, 2003), and (c) they are easy to administer and can be completed remotely (i.e., online) and therefore can reach a large sample size, improving statistical power, and can be measured with direct statistical comparisons to the population in question.

The term 'implicit' is also used to refer to what is being measured, and in this case it is assumed that it measures an attitude that is difficult to access introspectively. This kind of attitude can be described as unconscious within a dual processing model of human cognition (Fazio, 1990). In this model, all cognition can be divided into controlled and automatic processing systems – that which is conscious (controlled processing) and that which is unconscious (automatic processing).

This assumption of automaticity is that there is a mode of processing that is uncontrolled, unconscious, efficient, fast, unintentional, and stimulus driven (Moors et al., 2010). This means that this mode is not directed by conscious attention; it is founded on well-practised and

learned or habitual cognitions, helps us to make decisions very quickly and with minimal conscious effort, and can be initiated by stimuli in the environment.
Several other assumptions are not necessarily mandatory for using an implicit measure; these refer to one's theoretical position as to how an implicit measure might tap automatic cognitions. One idea is that reaction times in an implicit test are based on the stimulus (especially its meaning), the context (the nature of the task and on-going behavioural goals), and past experiences (Schwarz, 2007); another is that they are based on automatic evaluations of stimuli (e.g., Fazio, 2007). A common assumption is that reaction times are influenced by the relative strength of associations between mental representations (e.g., one might respond quickly to the target 'lights' when they are preceded by 'traffic' because of their strong association in memory – Carlston, 2010). In the next section, each of the main implicit measures is discussed in turn to explore their relative strengths and weaknesses, before moving on to discuss underlying mechanisms.

4. Implicit Methods

The most commonly researched implicit measure is the Implicit Association Test or IAT (Greenwald, McGhee & Schwartz, 1998). The task begins as a simple categorical good/bad judgement – the participant presses one key if a pleasant word is presented (e.g., "summer") and another key if an unpleasant word is presented (e.g., "cancer"). However, in the second phase of the task, a new concept is introduced, usually one based on a dichotomous attitude or preference (such as, racial, sexual, or brand preferences) and an association between one key press and one exemplar (e.g., white people) and another key press and the other exemplar (e.g., black people) is acquired. In this way, the participant acquires an association between a specific key press and the concept 'good' and an association between the same key press and 'white people'. They also acquire an association between another specific key press and the concept 'bad' and an association between the same key press and 'black people'. For individuals with a bias for white race, reaction times would be expected to be significantly faster during the compatible mapping phase than the incompatible mapping phase. When the pairs are switched such that 'good' and 'black' are now associated with the same key press, while 'bad' and 'white' are now associated with the same key press, for someone with a preference for white people, these switched trials are incongruent with that attitude. The prediction is that congruent trials yield faster response times than incongruent trials – it is easier to associate congruent concepts (good and white people) with the same key press than it is with incongruent concepts (good and black people). The IAT, and implicit measures like it, thus invite speeded categorical judgements that involve 'attitude objects' and response latencies can be used to infer an attitude or preference. This is an attractive alternative to subject-report measures, since it does not depend on any attempt to introspect; moreover, an implicit test is much harder to fake than a self-report test. The Harvard Project Implicit website provides a range of public IAT tests (Harvard University, 2011).

Tests of validity show that the racial IAT measure agrees with the different attitudes between white and black individuals (Nosek, Banaji, & Greenwald, 2002) and a homosexual IAT is able to differentiate between gay and straight males (Banse et al., 2001). However, there appear to be relatively low correlations between the IAT and self-report measures of the same attitude. This may be due to the likelihood that they tap different underlying cognitive structures (implicit versus explicit cognitions) as well as the limitations of self-reported measures outlined previously.

One criticism of the IAT is that it may merely tap 'extrapersonal associations' – it may be a measure of culturally shared assumptions rather than personal evaluations (Karpinski & Hilton, 2001). For example, this would argue that an IAT that detects a strong association between 'speeding' and 'bad' is just reflecting a participant's knowledge that society in the main judges speeding to be a bad thing, rather than this being the participant's personal automated attitude. For this reason, Olson and Fazio (2004) developed a modified IAT in which more personalised target categories are used (such as 'I like' and 'I don't like', rather than 'positive' and 'negative'). However, others, such as Gawronski and Bodehausen (2006) have asked how it could be conceivable that a culturally-shared influence could affect an implicit reaction over and above automatic, personal evaluations. Another criticism of the IAT is the reliance on the switching of blocks (the changes from the compatible to incompatible mapping phases).

Indeed, the effect is much stronger when the compatible mapping phase precedes the incompatible mapping phase than the other way around (Nosek et al., 2005). This is worrying because it means that the effect is too prone to changes in procedural issues.

Finally, the IAT has some serious practical limitations. Firstly, it is a relative measure between two categories – it does not offer an absolute measure of an attitude towards one target. This means that the measure D is a difference score and can show that one has a preference for one thing over another – yet if D were small and close to zero this would not tell us whether participants had an equally positive attitude to both targets or an equally negative attitude towards both targets (Blanton et al., 2006). Furthermore, one target may be preferred over another (e.g., one may think that 40 mph is a safer speed than 50 mph in a built-up area) but may not be preferred in an absolute sense (40 mph may still be viewed as unsafe). A related problem is that in the IAT, there is only one attribute category (e.g., good versus bad) and as we shall see later, other methods can have a larger range of attributes.

One way of ruling out the problems associated with switching blocks would be to use a **Single Block IAT** (SB-IAT). In this method, the screen is divided into upper and lower halves. The upper half is for compatible mapping trials and the lower half for incompatible mapping trials. Participants press E for negative words (for example) and I for positive words (regardless of where the positive and negative words appear on the screen). If the word 'black' appears in the upper half then the (racially biased) consistent mapping would be to press the E-key and to press the I-key if the word 'white' appears. However, if the word 'black' appears in the lower half then the required response is I (inconsistent mapping) and if the word 'white' appears, the required response is E. In a similar way to the IAT, if performance differences between the consistent and inconsistent mapping trials exist then they are assumed to reflect underlying associations between the two targets and the two attributes. This method does not rely on generating errors because there is no block switching and as such its reliability is reduced (Teige-Mocigemba et al., 2008).

The **Implicit Association Procedure** (IAP) method is an attempt to make the IAT more personal (and so reduce the potential influence of cultural values) by using a joystick rather than a key press. The joystick is moved backwards (towards oneself) when referring to self-consistent targets (so reflecting an approach behaviour) and forwards (away from oneself) when referring to self-inconsistent targets (so reflecting avoidance behaviour). It has been argued that this is more reliable way of measuring implicit associations (Schnabel et al., 2006).

The **Self-concept** (SELF-IAT) is another approach to reduce any influence of cultural values by using self and other terms in the test (Greenwald and Farnham, 2000). Concepts referring to the self might include one's first and last names, hometown, telephone number, birth month, or birth year, or they might include the terms I, me, mine versus others, they, theirs. It may be more valid to look at individual differences using the self-concept category with the variable of interest, rather than relying on the category of valence (good and bad). In an attempt to validate the method, Greenwald and Farnham (2000) showed that the SELF-IAT reliably demonstrated higher self-perceptions of femininity in females than in males.

The **Extrinsic Associative Simon Task** (EAST) is a colour discrimination task with attributes and targets that are to be ignored. White coloured words are to be responded to by their valence (positive or negative) by pressing the E or I keys. Blue words and green words are to be responded to on the basis of their colour (by pressing the E or I keys) even though they are attitude-related words. This can be seen as setting up compatible and incompatible mappings, with the assumptions that differences in reaction times between the two mappings reflect underlying associations between the attitude-related words and the valence categories (De Houwer, 2003). One problem is that the EAST is less reliable than the IAT (Teige et al., 2004).
To avoid the problem of having only a relative measure, rather than an absolute measure of an attitude towards a concept, one can simply remove one of the targets. In the Single Category IAT (SC-IAT) there is one target (e.g., 'black') and one attribute category with two anchors (e.g., 'good' versus 'bad'). After several trials, the anchors are switched, so setting up compatible and incompatible trials, but this time with only one category. Again, response differences between the two phases, before and after switching, can be used to infer underlying attitudes. While this can yield a more 'absolute' measure, it does not resolve the

problem of reliance on block switching (and hence the fact that the order of the blocks has a big impact on the size of the effect). In addition, the SC-IAT has a lower reliability than the IAT (De Houwer, 2003).

In the **Go/No-go Association Task** (GNAT) there are two main phases. In the first phase participants press a key (they 'go') when they see a target (e.g., 'black') or an attribute (e.g., 'bad') and do nothing (they 'no go') when they see a different target (e.g., 'white') or attributes (e.g., 'good'). In the second phase the attributes are reversed – the 'go' condition now applies to the alternative attribute (though the targets remain the same). So, now the key is pressed for 'black' and 'good' but not for 'white' and 'bad'. Once again these two phases correspond to compatible and incompatible mappings, and differences in response times between them can be used to infer attitudes. One problem with this method is that response times have too small a range, and so analysis is focussed on error rates (which tend to be more frequent than in the IAT procedure). This has an effect of lowering internal reliability (Nosek & Banaji, 2001).

The IAT and its variants have several strengths and can be a preferred approach to self-report methods but they also have several limitations. These include a reliance on block switching which can artificially induce errors, the small number of attributes that can be used, and the fact that the measures obtained are relative rather than absolute.

A somewhat different approach is the **Affective Priming Task**, which detects target words as either one affective category or another through the participant pressing a corresponding button or key on the keyboard. For example, the targets might be Good and Bad and the respondent has to press E if they see Good and I if they see Bad. In a second phase of the study, a prime appears before each target. Primes may be from the same categories as the targets. In some cases, the prime will be of the same category as the target word (e.g., the prime Fun followed by the target Good or the target Pain followed by the target Bad). In other cases the prime will be from the opposite category (e.g., Fun followed by the target Bad and or Pain followed by the target Good). The effect observed in the affective priming paradigm is speeded word detection times when the prime and target are from the same category than when they are from different categories, so the target Good will be detected sooner when it is preceded by Fun than when it is preceded by Pain. The affective priming task was developed by Fazio, Jackson, Dunton and Williams in 1995 to measure emotions. The method has been used to investigate a wide range of 'attitudes' such as, racial prejudice (Olson & Fazio, 2003; Denger & Wentura, 2010; Bertram, Schneider, & Ewaiwi, 2013), social anxiety disorder (Lange, Allart, Keijsers, Rinck & Becker, 2012), attitudes to light and dark skin tones (Stepanova & Strube, 2011), attitudes to foods with high fat content (Huggins, 2011), and attitudes toward sex (Macapagal & Janssen, 2011). It has also been used to identify sexual preference (Snowden, Wichter, & Gray, 2008) and perception of musical meaning (Steinbeis & Koelsch, 2010), attitude objects (Bargh, Chaiken, Govender & Pratto, 1992), newly learned foreign words (De Houwer, Hermans, & Eelen, 1998), and line drawings (Giner-Sorolla, Garcia, & Bargh, 1999.

5. Application of Implicit Measures in Driver Behaviour Research

The use of implicit tests in driving behaviour research is rare: only a handful of studies have used this method. These studies generally show that the method can be useful in the field as an addition to self-report measures. However, they do focus on the IAT rather than affective priming.

Hatfield, Fernandes, Faunce, and Job (2008) developed an IAT to measure attitudes towards speeding. It consisted of the categories Speeding/Risky Driving versus Keeping to Speed Limits/Safe Driving (and these were the categories shown as anchors for E and I key presses), to which seven speeding-related words and seven non-speeding-related words had to be categorised. The other categories were 'Good' and 'Bad' and seven pleasant and unpleasant words had to be categorised to these. The test works on the principle that for someone who dislikes speeding or has a negative attitude to speeding, the compatible mapping is the categories Speeding/Risky Driving with Bad and Keeping to Speed Limits/Safe Driving with Good, and the incompatible mapping is the categories Speeding/Risky Driving with Good and Keeping to Speed Limits/Safe Driving with Bad. Indeed results showed that the compatible

blocks produced shorter reaction times (Mean = 495 ms) than incompatible blocks (Mean = 920 ms1), so the test produces a score that indicates a negative attitude to speeding (when the score is greater than zero). Further tests of validity showed that this speeding IAT correlates with age, which is consistent with previous literature. Females also score significantly higher on the scale than males, and this is again consistent with the explicit measures. Driving tests on a car simulator showed that simulator speed correlates with the IAT, but only for higher speeds (e.g., 44 to 50 mph) and not for lower speeds (25 to 43 mph). However there were several self-report measures that it did not correlate with but that were expected to correlate with, such as the view that speeding is a major contributor to a road traffic accident. Overall, the test has therefore had some successes, but there are two problems with the category labels and the words lists used. Firstly, two categories refer directly to the dimension of valence (Good and Bad categories) but the speeding/no-speeding category labels contain words that may have positive and negative valence, such as Safe and Risky, respectively. Secondly, several of the speeding-related words could quite easily be classified as negative (such as, Blast, Rush, etc.) and several of the safe driving words could easily be classified as positive (e.g., Careful, Sensible, etc.). Therefore the test has been contaminated with words of obvious valence, when they should be related to an independent category. For example in the Racial IAT, two categories directly refer to valence, but the other two categories refer to ethnic groups (and hence any valence is subjective). This means that by including valence in the category labels and category attributes, any pure effect of speed-related attitude will be masked. This may explain why the IAT did not produce effects for slower speed on the driving simulator and why it did not correlate with some self-report items it ought to have correlated with (if the test is to be valid). Nonetheless, this study demonstrates that implicit measures can have great use in this area.

The other published articles that examined the IAT in the context of driving were Harre and Sibley (2007) and Sibley and Harre (2009). The first article described the development of IATs designed to measure self-perceived driving ability and self-perceived driving caution; two elements of the self-enhancement bias. This bias is the view that one is superior to others in driving ability and at less risk of having an accident. Of course, for some people this will be the case, they are better drivers than most, however, for others it will be a biased view (the fact that not everyone can be better than average has to reflect a biased perception). The IATs were based on Greenwald and Farnham's (2000) self-concept IAT. The driving ability attributes were expert driver, skilled driver, capable driver, competent driver, and useless driver, unskilled driver, hopeless driver, clumsy driver, and the driving caution attributes were careful driver, safe driver, responsible driver, law-abiding driver, and dangerous driver, careless driver, reckless driver, risky driver. The first study found that both IATs as well as an explicit measure of the self-enhancement bias were related to self-report of having received licence points for traffic violations. In the second study, the measures were taken before and after persuasive messages designed to alter attitudes to risky driving. While explicit measures were altered by viewing the messages, the implicit measures were not, and this can be explained by the dual process model described earlier, which assigns implicit processes to the unconscious system where automated and habitual processing takes place. These processes have been built up through years of personal experience and so cannot be easily modified.

One could question the choice of some of the attributes (e.g., repetition of the word driver might lead to participants ignoring it, and use of the prefix un and suffix less in several of the negative attributes might activate their corresponding positive antonyms), and it might be easier to associate un and less words with Other than with Self, which may produce the salience effect. However, this could be controlled for by finding alternative synonyms (e.g., poor driver rather than unskilled driver) and so the use of the SELF-IAT would then avoid several of the problems with the Hatfield et al. attributes i.e., it may make better sense to use the self-concept along with speed/risk-related driving attributes and safe driving attributes. This avoids the necessity of Good and Bad categories, which invoke the salience concept.
It is important to assess the validity of implicit measures over explicit measures and there are numerous examples. In the context of driving, Harre and Sibley (2007) found that both explicit and implicit methods that measure the self-enhancement bias of drivers (the belief that one is

[1] These means were estimated from the graph as actual values were not reported.

a better driver than others) were related to speed choice on a driving simulator and could predict the number of points accumulated for traffic violations. A further benefit of implicit measures is the difficulty with which they can be faked (unlike several explicit measures) as demonstrated by Vianello et al. (2010) explained earlier on this paper.

To conclude, the review has shown that unconscious attitudes may exist separately from conscious attitudes, and that measuring these unconscious attitudes using explicit methods such as self-report questionnaires is inappropriate. Many of the problems with explicit methods can be overcome using a more objective approach, such as the use of implicit reaction-time measures. The review also shows that implicit methods can be used in transport research independently or as a complementary method to current explicit methods (self-report, physiological measures, and qualitative methods). This would retain the advantages of explicit methods (ease of administration, the fact that some measures are good predictors and the fact that explicit methods measure aspects of driving that implicit method would not be able to) and counter some of their disadvantages. It may be useful to consider partial replications of the IAT studies carried in Australia or at least use them to inform the development of other implicit methods, such as, the priming tests.

References

af Wåhlberg, A., 2009. *Driver Behaviour and Accident Research Methodology.* s.l.:Ashgate Publishing Limited.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50, 179–211.

Arthur, W. & Graziano, W., 1996. The Five-Factor Model, Conscientiousness, and Driving Accident Involvement. *Journal of Personality.,* 64(3), pp. 593-618.

Arthur Jr, W., & Doverspike, D. (2001). Predicting motor vehicle crash involvement from a personality measure and a driving knowledge test. Journal of Prevention & Intervention in the Community, 22(1), 35-42.

Banse, R., Seise, J., & Zerbes, N. (2001). Implicit attitudes towards homosexuality: Reliability, validity, and controllability of the IAT. Zeitschrift für experimentelle Psychologie, 48(2), 145-160.

Bargh, J. A., Chaiken, S., Raymond, P. & Hymes, C., 1996. The Automatic Evaluation Effect: Unconditional Automatic Attitude Activation with a Pronunciation Task. Journal of Experimental Social Psychology, 32(1), pp. 104-128.

Bertram, J., Schneider, J. F. & Ewaiwi, A., 2013. Explicit and Implicit measures of prejudical attitudes toward muslims: on the relationship between explicit and implicit attitudes. In: K. S. Larsen, G. Vazov, K. Krumov & J. F. Schneider, eds. Advances in International Psychology: Researchy Approaches and Personal Dispositions, Socialization Processess and Organizational Behavior. Kassel Germany: Kassell University Press, pp. 45-62.

Blanton, H. & Jaccard, J., 2006. Tests of Multiplicative Models in Psychology: A Case Study Using the Unified Theory of Implicit Attitudes, Stereotypes, Self-Esteem, and Self-Concept. Psychological Review, 113(1), pp. 155-169.

Blincoe, K. M. Jones, A. P. Sauerzapf, V. & Haynes, R. (2006). Speeding drivers' attitudes and perceptions of speed cameras in rural England. Accident Analysis and Prevention, 38, 371-378.

Cacioppo, J. T., & Petty, R. E. (1989). Effects of message repetition on argument processing, recall, and persuasion. Basic and Applied Social Psychology, 10(1), 3-12.

Carlston, D., 2010. Models of Implicit and Explicit mental Representation. In: B. Gawronski & B. K. Payne, eds. Handbook of Implicit Social Cognition: Measurement, Theory, and Applications. New York: Guildford Press, pp. 38-61.

Corbett, C., 2001. Explanations for "understanding" in self-reported speeding behaviour. *Transportation Research Part F,* Issue 4, pp. 133-150.

Cote, J. A., & Buckley, M. R. (1987). Estimating trait, method, and error variance: Generalizing across 70 construct validation studies. Journal of Marketing Research, 315-318.

Deeprose, C., Andrade, J., Varma, S. & Edwards, N., 2004. Unconscious learning during surgery with propofol anaesthesia†. British Journal of Anaesthesia, 92(2), pp. 171-177.

Degner, J. & Wentura, D., 2010. Automatic Prejudice in Childhood and Early Adolescence. Journal of Personality and Social Psychology, 98(3), pp. 356-374.

De Houwer, J., 2003. The Extrinsic Affective Simon Task. Experimental Psychology, 50(2), pp. 77-85.

De Houwer, J., Hermans, D. & Eelen, P., 1998. Affective and Identity Priming with Episodically Associated Stimuli. Cognition and Emotion, 12(2), pp. 145-169.

Deffenbacher, J. L., Oetting, E. R. & Lynch, R. S., 1994. Development of a driving anger scale. *Psychology Reports,* 74(1), pp. 83-91.

DfT, 2011. *Reported Road Casualities in Great Britain:2011 Annual Report.* [Online] Available at: http://assets.dft.gov.uk/statistics/releases/road-accidents-and-safety-annual-report-2011/rrcgb2011-04.pdf
[Accessed 11 February 2013].

Dimofte, C. V., 2010. Implicit measures of consumer cognition: A review. *Psychology and Marketing,* Issue 27, pp. 921-937.

Eby, D. W., Molnar, L. J., Shope, J. T., Vivoda, J. M., & Fordyce, T. A. (2003). Improving older driver knowledge and self-awareness through self-assessment: The driving decisions workbook. Journal of safety research, 34(4), 371-381.

Fazio, R. H. (1990). A practical guide to the use of response latency in social psychological research.

Fazio, R. H., 2007. Attitudes as Objects-Evaluations Associations of Varying Strength. Social Cognition, 25(5), pp. 603-637.

Fazio, R. H. & Olson, M. A., 2003. Implicit measures in social cognition research: their meaning and uses. *Annual Review of Psychology,* Issue 54, p. 297–327.

Fazio, R. H., Jackson, J. R., Dunton, B. C. & Williams, C. J., 1995. Variability in Automatic Activation as an Unobtrusive Measure of Racial Attitudes: A Bona Fide Pipeline. Journal of Personality and Social Psychology, 69(6), pp. 1013-1027.

Fazio, R. H. & Zanna, M. P., 1978. Attitudinal qualities relating to the strength of the attitude-behavior relationship. *Journal of experimental social psychology,* 14(4), pp. 398-408.

Fernandes, R., Hatfield, J., & Soames Job, R. F. 2010. A systematic investigation of the differential predictors for speeding, drink-driving, driving while fatigued, and not wearing a seat belt, among young drivers. Transportation research part F: traffic psychology and behaviour, 13(3), 179-196.

Fleiter,J., Watson, B., Lennon, A., & Lewis, I. 2006. Significants others, who are they? – Examining normative influences on speeding. In: Proceedings 2006 Australian Road Safety Research Policing education Conference, Gold Coast.

Glasman, L. R., & Albarracín, D. (2006). Forming attitudes that predict future behavior: a meta-analysis of the attitude-behavior relation. Psychological bulletin, 132(5), 778.

Gawronski, B. & Bodenhausen, G. V., 2006. Associative and Propositional Processes in Evaluation: An Integrative Review of Implicit and Explicit Attitude Change. Psychological Bulletin, 132(5), pp. 692-731.

Greenwald, A. G. & Farnham, S. D., 2000. Using the Implicit Association Test to Measure Self-Esteem and Self-Concept. Journal of Personality and Social Psychology, 79(6), pp. 1022-1038.

Greenwald, A., McGhee, D. E. & Schwartz, J. L., 1998. Measuring individual differences in implicit cognition: The implicit association test. *Journal of Personality and Social Psychology,* 74(6), pp. 1464-1480.

Giner-Sorolla, R., Garcia, M. T. & Bargh, J. A., 1999. The automatic evaluation of pictures. Social Cognition, 17(1), pp. 76-96.

Gulian, E., Debney, L. M., Glendon, A. I., Davies, D. R., & Matthews, G. (1989). Coping with driver stress. In Stress and Tension Control 3 (pp. 173-186). Springer US.

Han, C. M., Lee, B. W., & Ro, K. K. (1994). The choice of a survey mode in country image studies. Journal of Business Research, 29(2), 151-162.

Harre, N. & Sibley, C., 2007. Explicit and implicit self-enhancement biases in drivers and their relationship to driving violations and crash-risk optimism. *Accident Analysis and Prevention,* Issue 39, pp. 1155-1161.

Harvard University. (2011). Project Implicit. Available: https://implicit.harvard.edu/implicit/aboutus.html. Last accessed 10th November 2013.

Hatfield, J., Fernandes, R., Faunce, G. & Job, R. S., 2008. An Implicit non-self-report measure of attitudes to speeding: Development and validation. *Accident Analysis and Prevention,* Volume 40, pp. 616-627.

Horvath, C.,Lewis, I., and Watson, B. 2012. Peer passenger identity and passenger pressure on young drivers speeding intentions. Transportation Research Part F, Issue 15, pp 52-64.

HM Government, 2013. *UK Road Accident Map.* [Online] Available at: http://data.gov.uk/search/apachesolr_search?filters=tid%3A644 [Accessed 11 February 2013].

Huggins, M., 2011. An exploration of the implicit food attitudes of people with Type-1 Diabetes using reaction-time and electrophysiological measures, Birmingham: University of Birmingham.

IRTAD, 2012. *Road Safety Annual Report 2011.* [Online] Available at: http://www.internationaltransportforum.org/Pub/pdf/11IrtadReport.pdf [Accessed 4 February 2013].

Jonah, B.A. 1997. Sensation seeking and risky driving: A review and synthesis of the literature. *Accident Analysis & Prevention*, *29*, 651-665.

Karpinski, A. & Hilton, J. L., 2001. Attitudes and the Implicit Association Test. Journal of Personality and Social Psychology, 81(5), pp. 774-788.

Lajunen, T., & Summala, H. (2003). Can we trust self-reports of driving? Effects of impression management on driver behaviour questionnaire responses. Transportation Research Part F: Traffic Psychology and Behaviour, 6(2), 97-107.

Lajunen, T. & Parker, D., 2001. Are aggressive people aggressive drivers? A study of the relationship between self-reported general aggressiveness, driver anger and aggressive driving. *Accident Analysis and Prevention,* 33(2), pp. 243-255.

Lane, K. A., Banaji, M. R., Nosek, B. A. & Greenwald, A. G., 2007. Understanding and Using the Implicit Association Test: IV What We Know (So Far) about the Method. In: B. Witterbrink & N. Schwarz, eds. Implicit Measures of Attitudes. New York: Guildford Press, pp. 59-102.

Lange, W.-G.et al., 2012. A Neutral Face Is Not Neutral Even if You Have Not Seen It: Social Anxiety Disorder and Affective Priming with Facial Expressions. Cognitive Behaviour Therapy, 41(2), pp. 108-118.

Lenzner, T., Kaczmirek, L., & Lenzner, A. (2010). Cognitive burden of survey questions and response times: A psycholinguistic experiment. Applied Cognitive Psychology, 24(7), 1003-1020.

Macapagal, K. R. & Janssen, E., 2011. The valence of sex: Automatic affective associations in erotophilia and erotophobia. Personality and Individual Differences, Issue 51, pp. 699-703.

MacLeod, C., Mathews, A. & Tata, P., 1986. Attentional Bias in Emotional Disorders. *Journal of Abnormal Psychology,* 95(1), pp. 15-20.

Moors, A., Spruyt, A. & De Houwer, J., 2010. In Search of a Measure That Qualifies as Implicit. In: B. Gawronski & K. B. Payne, eds. Handbook of Implicit Social Cognition: Measurement, Theory, and Applications. New York: Guildford Press, pp. 19-37.

Musselwhite, C. B. A. (2006), Attitudes Towards Car Driving Behaviour: Categorising and Contextualising Risk. *Accident Analysis and Prevention*, 38, 324-333

Musselwhite, C. B. A. and Haddad, H. (2010). Exploring older drivers' perceptions of driving. *European Journal of Ageing*. 7(3), 181-188

Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental processes. Psychological review, 84(3), 231.

Nosek, B. A. & Banaji, M. R., 2001. The go/no-go association task (GNAT). *Social Cognition,* Issue 19, pp. 625-666.

Nosek, B. A., Banaji, M. R. & Greenwald, A. G., 2002. Harvesting Implicit Group Attitudes and Beliefs From a Demonstration Web Site. Group Dynamics: Theory, Researc, and Practice, 6(1), pp. 101-115.

Nosek, B. A., Greenwald, A. G. & Banaji, M. R., 2005. Understanding and Using the Implicit Association Test: II. Method Variables and Construct Validity. Personality and Social Psychology Bulletin, 31(2), pp. 166-180.

Oskamp, S. & Schultz, P. W., 2005. *Attitudes and Opinions.* s.l.:Psychology Press.

Schnabel, K., Banse, R. & Asendorpf, J., 2006. Employing automatic approach and avoidance tendecies for assessment of implicit personality self-concept: The Implicit Association Procedure (IAP). Experimental Psychology, 53(1), pp. 69-76.

Schwarz, N., 2007. Attitude Construction: Evaluation in Context. Social Cognition, 25(Special Issue), pp. 638-656.

Sibley, C. G. & Harre, N., 2009. The impact of different styles of traffic safety advertisement on young drivers' explicit and implicit self-enhancement biases. *Transportation Research Part F,* Issue 12, pp. 159-167.

Snowden, R. J., Wichter, J. & Gray, N. S., 2008. Implicit and Explicit Measurements of Sexual Preference in Gay and Heterosexual Men: A Comparison of priming Techniques and the Implicit Association Task. Archives of Sexual Behavior, Issue 37, pp. 558-565.

Steinbeis, N. & Koelsch, S., 2011. Affective Priming Effects of Musical Sounds on the Processing of Word Meaning. Journal of Cognitive Neuroscience, 23(3), pp. 604-621.

Stepanova, E. V. & Strube, M. J., 2012. The role of skin color and facial physiognomy in racial categorization: Moderation by implicit racial attitudes. Journal of Experimental Social Psychology, Issue 48, pp. 867-878.

Tiege, S., Schnabel, K., Banse, R. & Asendorpf, J. B., 2004. Assessment of Multiple Implicit Self-Concept Dimensions Using the Extrinsic Affective Simon Task (EAST). European Journal of Personality, Issue 18, pp. 495-520.

Teige-Mocigemba, S. & Klauer, K. C., 2008. 'Automatic' evaluation? Strategic effects on affective priming. Journal of Experimental Social Psychology, Issue 44, pp. 1414-1417.

Vianello, M., Robusto, E. & Anselmi, P., 2010. Implicit conscientiousness predicts academic performance. *Personality and Individual Differences,* Issue 48, pp. 452-457.

Wallén Warner, H. & Åberg, L., 2008. Drivers' beliefs about exceeding the speed limits. *Transportation Research Part F,* Issue 11, pp. 376-389.

WHO, 2009. *Global status report on road safety: time for action.* [Online] Available at: http://www.who.int/violence_injury_prevention/road_safety_status/2009/en/ [Accessed 11 February 2013].

Zajonc, R. B., 1968. Attitudinal Effects of Mere Exposure. *Journal of Personality and Social Psychology Monograph Supplement,* 9(2), pp. 1-27.

Warner, S. L. (1965). Randomised response: A survey technique for eliminating evasive an-

swer bias. Journal of the American Statistical Association 60: 63–69.

Wilson, T. D. (2002). Strangers to ourselves: Discovering the adaptive unconscious. Bellknap Press of Harvard University Press.