WIP - Supporting road safety by analyzing social representations of automated vehicles

Oriane Mouton
Laboratoire Sciences de la Cognition, Technologie, Ergonomie (SCoTE EA 7420), INU Champollion
France
University of Toulouse
France
oriane.mouton@univ-jfc.fr

Julien Cegarra
Laboratoire Sciences de la Cognition, Technologie, Ergonomie (SCoTE EA 7420), INU Champollion
France
University of Toulouse
France
julien.cegarra@univ-jfc.fr

Jordan Navarro
Laboratoire d'Etude des Mécanismes Cognitifs (EA 3082), Université Lyon 2
France
jordan.navarro@univ-lyon2.fr

Abstract

Automated Vehicles (AVs) have the capability to manage all driving tasks, ranging from navigation decisions to vehicle control under various conditions. They are central to numerous discussions and are perceived as key factors in enhancing traffic flow, safety, and mobility. However, drivers of Conventional Vehicles (CVs) may adjust their behaviors in response to the introduction of AVs, such as by reducing their safety margins [15]. This study aims to prospectively explore the reasons behind potential behavioral changes in CV drivers using the theoretical framework of Social Representations (SR). One of the functions of SR is to guide behaviors and practices by providing meaning to our actions [1]. Additionally, SRs have been utilized to foster greater engagement [2]. This paper presents preliminary results derived from two social psychology methods: free and hierarchical associations, and a Test of Context Independence (TCI) to identify the central core of SR. The findings raise questions about the similarities between the SRs associated with AVs and CVs. Although this research is ongoing and will incorporate additional complementary methods, the initial results already offer valuable insights for adapting road safety measures to make them more specific and engaging.

CCS Concepts

• **Applied computing** → Psychology.

Keywords

Automated Vehicle, Social Representations, Road Safety, Prospective Ergonomics

ACM Reference Format:
Oriane Mouton, Julien Cegarra, and Jordan Navarro. 2024. WIP - Supporting road safety by analyzing social representations of automated vehicles. In *European Conference on Cognitive Ergonomics (ECCE 2024), October 08–11, 2024, Paris, France*. ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/3673805.3673853

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s).
ECCE 2024, October 08–11, 2024, Paris, France
© 2024 Copyright held by the owner/author(s).
ACM ISBN 979-8-4007-1824-3/24/10
https://doi.org/10.1145/3673805.3673853

1 Introduction

1.1 Context

Automated Vehicles (AVs) are responsible for all driving activities, from navigation decisions to vehicle control at all times. They lie at the core of numerous issues and are perceived as factors in improving traffic flow, mobility, and road safety [15]. The Society of Automotive Engineers (SAE) defines six levels of vehicle automation: Level 0 denotes no automation, Levels 1 to 3 involve increasing levels of automation with human oversight, and Levels 4 and 5 describe vehicles that are partially or fully autonomous, requiring no driver except in certain scenarios.

However, the widespread adoption of autonomous vehicles will not be instantaneous. It is projected that by 2060, only half of American traffic will be autonomous [10]. Therefore, it is expected that various levels of automation will coexist on the roads, resulting in mixed traffic environments. This perspective aligns with Rogers' diffusion of innovation curve [19], which suggests that the adoption of new technologies follows a gradual process where "innovators" and "laggards" coexist.

Our focus is on the potential behavioral adaptations of conventional car drivers in mixed-traffic settings. Studies on the causes of accidents in traffic shared with AVs indicate that a primary cause of accidents is the lack of experience among drivers regarding the operation of AVs. This inexperience, coupled with behaviors such as driving too closely or too fast behind an AV, contributes to an increase in rear-end collisions [7, 15]. To anticipate these potential behavioral changes, we propose examining the field of Social Representations (SRs) of AVs.

1.2 Literature

1.2.1 Representations and Social Representations (SRs). The concept of "representation" has been utilized in cognitive sciences for some time, with related terms including mental models, schemas, scripts, and mental images [18]. Representations can be either "transitory," constructed in real-time during a task to facilitate interpretation, or "stored in memory", structuring and stabilizing our knowledge in long-term memory [5]. Representations serve as an "essential medium" between our perceptions and our actions, and cognitive activity can be summarized as the activation and acquisition of representations [4]. Thus, we have one aspect focused on understanding and another on knowledge acquisition and construction. Richardson and Ball distinguish between "pre-constructed" representations, which reflect long-term, stable knowledge, and "simultaneously constructed" representations, which are developed dynamically in response to tasks and are more mutable [18].

In the field of social cognition, these notions of representations are also present, focusing on how individuals process information. However, Molinier and Rateau contrast social cognition with the theory of SRs [16]. These two frameworks have long co-existed without significant integration, yet a dual link can be established between the individual aspect of social cognition and the collective aspect of SRs. On one hand, the processes of social cognition contribute to the development of SRs, with elements such as categories, stereotypes, and causal attributions found in the content and structure of SRs. While SRs are collective, they are also constructed by individuals. On the other hand, the process of social cognition can be modulated by SRs, as individual cognition is based on collective beliefs.

1.2.2 Social Representations (SRs). The theory of SRs was developed by Moscovici [14], who emphasized its importance for understanding the dynamics of social interactions and the determinants of behavior. SRs provide a "functional vision of the world" allowing individuals or groups to make sense of their actions and understand reality through their system of references [1]. Abric [1] defines a structural approach to SRs, with a stable, resistant central core and a dynamic, context-dependent peripheral system. Three aspects need to be investigated when studying SRs: content, structure, and context. Abric identifies four functions of SRs: (1) understanding and explaining reality, (2) defining identity, (3) guiding behaviors and practices, and (4) justifying positions and behaviors. SRs can thus be considered as "guides to action,". According to Moscovici, SRs consist of organized and structured information, beliefs, attitudes, and opinions about an object. To fully account for the components of SRs, a triangulation of methods is required, each with a specific objective. For instance, interviews are essential for studying SRs and their context. Other methods, such as free association (eliciting words related to an object) and hierarchical evocation (ranking the importance of each elicited word), are more specific to the structure and content of SRs [6]. Methods like the Test of Context Independence (TCI) aim to confirm the structure of SRs [11].

1.2.3 SRs and road safety. The automation of vehicles represents a significant change, transforming the driver's role. More broadly, the development of artificial intelligence and digital technology for AVs "crystallizes several fears" [13]. The representation of AVs and its evolution with these technologies is a pertinent question, particularly given the literature on road safety in social psychology, which remains "a vast undeveloped field" [8]. The study of SRs of new technologies is also underrepresented, especially regarding their integration into daily life [16]. Examining the SRs of AVs in mixed road traffic contexts offers an innovative perspective, combining the integration of new technologies with the impact on individuals' behavioral adaptations concerning road safety, with a focus on prevention.

2 Aim of the study and hypotheses

This exploratory study has multiple objectives corresponding to the methods required for examining SRs of AVs. The objectives are: (1) to explore the content of AVs' SRs using free associations, (2) to determine their structure and central core using the Test of Context Independence (TCI), and (3) to investigate the context of these SRs through interviews. We conducted two successive online questionnaires with different samples of participants. This article aims to present the preliminary results (work in progress) from the first two questionnaires of the study on the representations of AVs.

3 Methods

3.1 First questionnaire: free associations

3.1.1 Participants. A total of 373 participants took part in the free association questionnaire. They were randomly assigned to one of two conditions: Automated Vehicles (AVs) or Conventional Vehicles (CVs). The AVs' condition (n=183) included 115 women, 67 men, and 1 other. The CVs' condition (n=190) included 109 women and 81 men. The mean ages were 40 years (min=18; max=79; SD=15.6) and 38.6 years (min=18; max=78; SD=14.3), respectively.

3.1.2 Procedure and material. Participants were asked to list five words they consider representative of either AVs or CVs (two different groups). They then ranked these five words from most to least important and assigned each an emotional valence (positive, neutral, or negative). The analysis of free associations is prototypical, highlighting the salience of certain elements by crossing two criteria: frequency of appearance and rank of evocation [21]. Abric adds the notion of importance with the method of hierarchical evocations [1]. Important and frequent items constitute the central core and the others the periphery of the representation. Lexical analyses were conducted using IRaMuTeQ.

3.2 Second questionnaire: Test of Context Independence (TCI)

3.2.1 Population. To date, 39 participants (25 women, 13 men, and 1 other) have completed the TCI questionnaire. The mean age was 36.7 years (min=19; max=65; SD=12). Data collection is still ongoing, with a target of reaching 200 participants.

3.2.2 Procedure and material. Given the spontaneous nature of the free association method, we did not provide a definition to avoid influencing the participants. However, for the TCI, we decided to give a brief and neutral definition to provide a common base of knowledge: an AV is a vehicle that can take over the driving activity without human intervention.

After analyzing the free association results (prototypical analysis), we identified a list of potentially central items (words from the free associations central core). We also included some peripheral elements of the SR and elements from the CVs' SR. A total of 26 items were selected and presented to participants in random order. Each item was phrased as follows: "In your opinion, is an autonomous vehicle always, in all cases, a means of transport that [item, e.g., 'is driverless']." Participants responded on a four-point scale: (1) "definitely no", (2) "rather no", (3) "rather yes", (4) "definitely yes".

Table 1: Central core structure verification

Items with a score above the Dmax threshold	Comparison with the structure from free associations
cost	Periphery
responsibility	Periphery
comfort*	Central core
fear	Periphery
risk	Periphery
robot*	Central core

* Items with a score above the Dmax threshold (Dmax = 78.2226) and from the central core of AVs' SR.

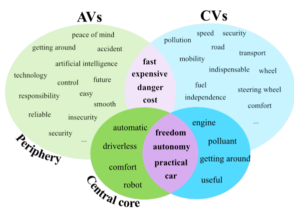

Figure 1: AVs and CVs' structure and content comparison

We used the Dmax index of the Kolmogorov-Smirnov test to determine the threshold at which the propensity to answer 3 and 4 for an item does not differ significantly from 100% [12]. Items meeting this criterion are considered part of the central core.

$$Dmax = [(1 - 1.36/\sqrt{n}) * 100]$$

4 Results

4.1 Free associations

The free association task regarding AVs yielded 915 words, with a hapax rate of 25.35% (232 unique words) and 950 words, with a hapax rate of 17.05% (162 unique words) for CVs. The respective polarity indexes (0.13, 0.31) suggest a generally neutral representation. It is defined as (positive words - negative words) / total words, to assess if the SR is positive (>0.4) or negative (<-0.4). Whereas the neutrality indexes (-0.43, -0.50) indicate a higher proportion of positive and negative items compared to neutral ones. It is defined as (neutral words - sum of positive and negative words) / total words, it helps determine whether a neutral polarity index arises from a majority of neutral words (>0.4) or a majority of positive and negative words (<-0.4). We conducted for each condition a prototypical analysis of elements with a minimum frequency of 5, main results are shown in Figure 1.

Using Hierarchical Descending Classification (HDC) [17], we clustered AVs' items based on their proximity and co-occurrence into classes. Each class was assigned a general theme, grouping the most associated items. We have identified 3 themes: general characteristics (future, Tesla, electric, risk, etc.), disadvantages and consequences (danger, accident, responsibility, insecurity, etc.), and benefits (security, freedom, simplicity, peace of mind, etc.).

4.2 TCI

The TCI allowed us to verify the centrality of the representation core. Items with a response propensity of 3 or 4 above the Dmax threshold (Dmax = 78.2226) are considered part of the central core. They are presented in Table 1. The second column presents a comparison of the results from free associations.

5 Discussion

5.1 Towards a representational model

These preliminary results suggest that the SR of AVs shares elements with the SR of CVs. The common elements, particularly within the central core, raise questions since a representation is fundamentally different when its central core differs [1]. Based on the data from the free associations alone, it is challenging to define a distinct representation of AVs. However, the TCI has helped refine our results and specify the central core for AVs.

As data collection is still ongoing, a comprehensive discussion of the results is not yet possible. Nevertheless, it is noteworthy that elements such as "comfort" and "robot" are part of the central core. Other interesting findings have emerged. While we can currently identify only two elements in the central core, some peripheral elements from the free associations show a response propensity of 3 or 4 higher than the Dmax index, including "cost", "artificial intelligence", "responsibility", etc. This suggests that the SR of AVs is part of a broader context, as indicated by the comparison of free associations, and highlights the importance of distinguishing AVs from CVs to better understand the centrality of AVs' representations.

Starting from the themes, a model of AVs' SR seems to appear. Certain themes stand out: autonomy, danger, characteristics, and benefits. In Figure 2, we visualize the clusters determined by the HDC: general characteristics are mainly at the bottom, disadvantages and consequences are in the center, and benefits are at the top.

These initial findings also highlight contrasting themes such as "danger" versus "safety" and "peace of mind" versus "awareness". Given the extensive scientific literature addressing trust in AVs [20], and the general consensus that individuals tend to express trust, we are prompted to question the source of this trust when terms like "danger" and "accident" are frequently mentioned. It

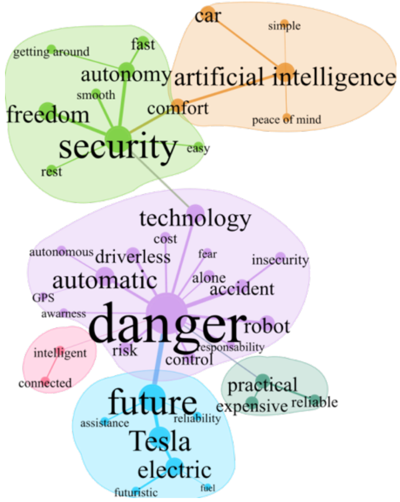

Figure 2: AVs' representation model based on the analysis of similarities

begs the question of why "security" is central while these concerns remain peripheral, despite their intrinsic relevance within the context. Therefore, we need to consider and understand the current context surrounding AVs to interpret how individuals perceive and reconcile the potential risks and benefits associated with AV technology.

5.2 Limits and prospects

During the study design, decisions were made regarding whether to provide a definition of AV. One limitation is the lack of context for the SR. It's important to investigate the content, structure, and context of the representations. We focused on content and structure but need to supplement these findings with interviews. We conducted a quantitative analysis using IRaMuTeQ software, but adding a qualitative analysis outside the framework of our preliminary quantitative results would be beneficial to identify additional themes and compare them with the quantitative findings. We plan to adapt the Implicit Association Test (IAT) [9] to distinguish between AVs and CVs more accurately. This categorization task will help us determine the extent to which an item is categorized as belonging to AV rather than CV. This approach will provide a new perspective, complementing our results with a method from outside the field of SRs.

A longer-term perspective is to use these results to design appropriate road safety measures. If we identify certain representations among specific types of populations (age, driving habits, driving experience, most frequently used type of road, etc.), we can tailor prevention strategies around the core of their representation. Studies [2, 3] have shown the importance of studying SRs for engaging communication, particularly the use of items from the central core of the representation. It is therefore relevant to verify which elements are common to all, which are specific, and to which people they are specific.

References

[1] Jean-Claude Abric. 2016. Pratiques sociales et représentations. Puf.
[2] Mathilde Barbier, Ladislav Moták, Camille De Gasquet, Fabien Girandola, Nathalie Bonnardel, and Grégory Lo Monaco. 2019. Persuasive Technology, Social Representations and Ergonomics of Interfaces: A New Theoretical Articulation. Persuasive Technology: Development of Persuasive and Behavior Change Support Systems, Springer International Publish-ing, 362–373.
[3] Eric Bonetto, Fabien Girandola, and Grégory Lo Monaco. 2018. Social Representations and Commitment. European Psychologist 23, 3: 233–249.
[4] Thibaut Brouillet. 2011. Juger un objet comme agréable ou désagréable: théories représentationnelles versus théories de l'auto-organisation. In Peut-on se passer de représentations en sciences cognitives?. Paris, 105–113.
[5] Françoise Cordier, Jacques Crépault, Guy Denhière, Jean-Michel Hoc, Christian George, and Jean-François Richard. 1990. Connaissances et représentations. In Traité de psychologie congitive 2: le traitement de l'information symbolique. Paris.
[6] Lionel Dany, Isabel Urdapilleta, and Grégory Lo Monaco. 2015. Free associations and social representations: some reflections on rank-frequency and importance-frequency methods. Quality & Quantity 49, 2: 489–507.
[7] Francesca Favarò, Sky Eurich, and Nazanin Nader. 2018. Autonomous vehicles' disengagements: Trends, triggers, and regulatory limitations. Accident Analysis & Prevention 110: 136–148.
[8] Marie-Axelle Granié. 2016. Représentations sociales et sécurité routière. In Les représentations sociales. Théories, méthodes et applications. DeBoeck, 279–294.
[9] Anthony G Greenwald, T Andrew Poehlman, Eric Luis Uhlmann, and Mahzarin R Banaji. 2009. Understanding and Using the Implicit Association Test: III. Meta-Analysis of Predictive Validity. Journal of Personality and Social Psychology 97, 1: 17–41.
[10] Todd Litman. 2023. Autonomous Vehicle Implementation Predictions: Implications for Transport Planning. Vic-toria Transport Policy Institute.
[11] Grégory Lo Monaco, Florent Lheureux, and Séverine Halimi-Falkowicz. 2008. Test d'indépendance au contexte (TIC) et structure des représentations sociales. [Test of context independence (TCI) and structure of social representations.]. Swiss Journal of Psychology / Schweizerische Zeitschrift für Psychologie / Revue Suisse de Psychologie 67, 2: 119–123.
[12] Grégory Lo Monaco and Patrick Rateau. 2016. Méthodes d'étude de la structure des représentations sociales. In Les représentations sociales. Théories, méthodes et applications. DeBoeck, 135–144.
[13] Marie-Julie Loyer-Lemercier. 2020. Les risques émergents des nouvelles mobilités : la voiture autonome. Archives de philosophie du droit 62, 1: 299–307.
[14] Serge Moscovici. 1961. La représentation sociale de la psychanalyse. Bulletin de psychologie 14, 194: 807–810.
[15] Đorđe Petrović, Radomir Mijailović, and Dalibor Pešić. 2020. Traffic Accidents with Autonomous Vehicles: Type of Collisions, Manoeuvres and Errors of Conventional Vehicles' Drivers. Transportation Research Procedia 45: 161–168.
[16] Patrick Rateau and Pascal Moliner. 2009. Représentations sociales et processus sociocognitifs. Presses Universi-taires de Rennes.
[17] Max Reinert. Une méthode de classification descendante hiérarchique: application à l'analyse lexicale par contexte.
[18] Miles Richardson and Linden J. Ball. 2009. Internal representations, external representations and ergonomics: to-wards a theoretical integration. Theoretical Issues in Ergonomics Science 10, 4: 335–376.
[19] Everett Rogers. 2003. The Diffusion of Innovations. New York.
[20] Shubham Soni, Nagarjun Reddy, Anastasia Tsapi, Bart van Arem, and Haneen Farah. 2022. Behavioral adaptations of human drivers interacting with automated vehicles. Transportation Research Part F: Traffic Psychology and Behaviour 86: 48–64.
[21] Pierre Vergès. 1994. Approche du noyau central: propriétés quantitatives et structurales. In Structures et transfor-mations des représentations sociales. Delachaux et Niestlé, 233–253.