ANALYZING THE CHANGING RELATIONSHIPS A SOCIETY FACES WITH THE ADOPTION OF AUTONOMOUS VEHICLES

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

Public transportation becomes quite prevalent in crowded cities such as New York City or San Francisco. Since it may be expensive for city residents to keep and maintain a car of their own, they may rely on alternate modes of transportation, such as shuttle services or metro buses. For example, in Jersey City, nearly 40% of residents are without a vehicle, as the city officials encourage pedestrians, rather than zoning to traffic patterns, (Maciag, 2015). In general, public transportation can be quite advantageous in enhancing the economics and health of a community. For instance, public transit can increase business sales, promote users to walk to and from stations, and lead to less gas usage which reduces pollution, (Berggren, 2020). However, this system of travel (e.g. shuttle buses), usually require an individual to drive the vehicle to help residents access all areas of a city. Since these services are offered along the same routes, an autonomous vehicle could take its place, possibly allowing a more efficient and safer ride without the cost of a driver completing a tedious task. Autonomous vehicles can also help consumers on an individual level by aiding them during long journeys or reducing traffic accidents.

Autonomous vehicles, also known as driverless vehicles, use a fully automated driving system that results in the vehicle responding to external conditions the way human drivers do. One great advantage of this technology includes a potential increase in safety for drivers, passengers, and pedestrians. The software used in these vehicles is less likely to make as many errors as humans would on the road, resulting in a decrease of casualties caused by vehicle crashes. Another advantage of autonomous vehicles includes the ability for many kinds of people to drive, including those that may be disabled or elderly. Since the vehicles take control over the drive, it's easier for anybody to take the wheel of an autonomous vehicle. Lastly, automated cars

may eliminate driver fatigue and allow some to sleep during overnight journeys, ("What is an Autonomous Vehicle?", 2020). With these advantages, it is easy to see that the arrival of automated cars can affect a society drastically.

In this paper, I will discuss the ways in which the adoption of autonomous cars can alter the civilization and culture of an area. First, I will analyze the change in relationship between city residents and their manually driven cars vs. their autonomous vehicles. For instance, all drivers trust their cars. However, this trust can change when the driver is not doing all the work anymore. They may have to place some trust on the software their car uses, instead of placing more in themselves. Additionally, as the drivers will have opportunities to pursue other activities during travel, they may view their vehicles in a different manner. To analyze this potential shift in thinking, I have looked into past researchers who have interviewed candidates and thoroughly observed this potential change. Then, I will discuss the shift in perspective from a pedestrian point of view. Pedestrians will regard cars driven using software in a different manner than cars driven by humans. For instance, a pedestrian may trust software to make less mistakes at intersections in comparison to humans. They may also have diverse thoughts on their ability to communicate with drivers of autonomous vehicles who are either not present or unengaged. To gather information on this subject, I have interviewed various pedestrians on their thoughts and looked into past studies on how the perspective of pedestrians can vary. Lastly, I will look into general amendments a society must make, including new challenges the areas must overcome to fully adjust to a life with autonomous vehicles. Some examples of changes an area must make, include adapting to differing traffic patterns or parking arrangements.

Autonomous Vehicles: How do they work?

To properly analyze how adopting autonomous vehicles can change society, the inner mechanisms of how they work must be thoroughly explored. First, a driver sets a destination and the car's software calculates a route. Autonomous vehicles contain a rotating, roof-mounted LIDAR sensor that monitors a 60-meter range around the car, (Ondruš, Kolla, Vertaľ, & Šarić, 2020). Consequently, this creates a dynamic 3-dimensional map of the car's current environment. The vehicles also contain sensors that detect its place relative to the 3D map and calculate distances between obstacles, (Ondruš, Kolla, Vertaľ, & Šarić, 2020). Additionally, there is an override function available for humans to take control of the vehicle.

A significant technology that autonomous cars use is Machine Learning (ML) and Deep Neural Networks (DNNs). A key component of an autonomous vehicle, as mentioned before, is a perception module which senses its surroundings. This module is controlled by an underlying DNN which takes inputs from different sensors to maneuver the car safely under the current conditions. These sensors include radar, laser light, GPS, odometers, and computer vision to interpret sensory information, identify appropriate navigation paths, and calculate any obstacles. LIDAR, Light Detection and Ranging, is a remote sensing technology that measures distance by illuminating a target with a light beam and analyzing reflected light, (Ondruš, Kolla, Vertaľ, & Šarić, 2020). Radar, Radio Detection and Ranging, can estimate the velocity of objects using electro-magnetic waves. Ultrasonic sensors and video cameras are used to detect objects near the mirror on all sides of the vehicles. Lastly, GPS, Global Positioning System, is a space-based satellite navigation system that provides current location and time information from an unobstructed line of sight from satellites, (Ondruš, Kolla, Vertaľ, & Šarić, 2020). A typical DNN is composed of multiple layers stacked together to extract various representations of the

input from the information provided by the sensors (Tian, Pei, Jana, & Ray, 2018). For example, the first few layers of an autonomous car DNN can extract basic information such as stop signs or other cars, whereas the final layer calculates decisions such as the direction to steer, (Tian, Pei, Jana, & Ray, 2018). Each layer of a DNN consists of computing units called, neurons, which are connected together to form each layer and send outputs to one another, (Tian, Pei, Jana, & Ray, 2018).

It is important to note that despite tremendous progress with DNNs and autonomous cars, the software can demonstrate incorrect or unexpected corner-case behaviors that can lead to dangerous consequences, (Tian, Pei, Jana, & Ray, 2018). There have even been several real-world cases where crashes under rare previously seen cases occur. For example, a fatal Tesla crash resulted from a failure to detect a white truck against the bright sky, (Tian, Pei, Jana, & Ray, 2018). These erroneous behaviors can be fixed through bug detection and a patching cycle; however, this is a very challenging problem. Large companies like Google and Tesla have indicated so as well, despite having already deployed machine learning techniques in production environments, (Tian, Pei, Jana, & Ray, 2018).

Technological Momentum

An important STS topic to consider when exploring the question of how autonomous vehicles can change society, is technological momentum. This theory observes the relationship between technology and society over time. The idea is that both are reciprocal and time-dependent – one does not determine the changes in the other, but both influence each other simultaneously (Definitions, 2020). In other words, technology shapes society and social practices in some way. For instance, researchers have found that technology can affect learning, particularly educational uses of technology, (Oliver, 2011). This theory was formed by Thomas

P. Hughes from two separate models of how society and technology interact. The first is technological determinism, which claims that society is affected and modified by the introduction of a new technology in an irreversible way. The other model is social determinism, which asserts that society controls how a technology is used and developed. Technological momentum combines these two models and adds time into the equation (Wikipedia, 2018). When the technology is young, society has more control over its use and scope. However, as the technology matures, it becomes integrated into society, achieving a technological momentum of its own, making it increasingly difficult to steer by users. Therefore, technology and society follow a social determinism model first, but evolve into technological determinism over time, as the technology becomes more prevalent (Povlock, 2016).

The idea of social and technological determinism can be applied to a society adopting autonomous vehicles. At first, society will have more control over the effects of autonomous vehicles, mainly drivers will choose how they differ in spending their time on the road. A main concern is that this may include the shift to activities passengers usually do when being driven as a passenger. Research shows that drivers tend to use slow-moving traffic to undertake business related work such as taking phone calls and filling out paperwork, (Bissell, Birtchnell, Elliott, & Hsu, 2018). Additionally, when a driver is released from driving, a car could become a new mode of both private and professional residence, (Bissell, Birtchnell, Elliott, & Hsu, 2018), therefore creating a different relationship between a driver and their car. This differing relationship is what can shift a society to technological determinism. Considering your vehicle as a sanctuary or place of privatism can increase the usage of these vehicles and change travel planning and scheduling on a grand scale. For example, starting a new commute can involve experimenting with differing modes of transport which help inform people about the best choice

for them. When there is an increased convergence between autonomous vehicles and people's schedules, they will plan differently, (Bissell, Birtchnell, Elliott, & Hsu, 2018). This variation in planning will eventually influence the values and preferences of an entire city and possibly the organization of urban spaces. Autonomous vehicles will likely become more prevalent in the area, thereby increasing the number of vehicles on the road and need for parking spaces, (Bissell, Birtchnell, Elliott, & Hsu, 2018). Additionally, the autonomous support will make travel more favorable which could affect the way people opt to live, possibly farther away from work, (Bissell, Birtchnell, Elliott, & Hsu, 2018).

Non-Users

Another important STS framework to consider with the adoption of autonomous cars is in relation to non-users. So far, users of autonomous vehicles and car drivers in a city have been explored. However, an STS theory related to User Studies discusses the significance of non-users of a technology to be as important as the users. Sally Wyatt, the author of "Non-Users Also Matter: The Construction of Users and Non-Users of the Internet" details the users and non-users of the internet (Wyatt, 2003). She starts off by discussing her own experiences of choosing not to drive automobiles and opting to become a non-user of the technology. For Wyatt, this has made a profound effect on her life as she sees cars as a threat to her well-being when she is walking, riding a bicycle, or using public transportation. Wyatt makes a point, throughout the paper, that non-users should be evaluated with users to have a complete perspective on the impact technology can make on society. For example, this technique can discover the reasons for why technologies can fall short for some consumers. In the rest of her paper, she emphasizes that certain people may not need to over-complicate their lives by using internet if they have cheaper alternatives to fit their needs. Therefore, this theory highlights that non-users should be

separately observed when getting feedback on a technology or gathering information about its effects on society, (Wyatt, 2003). As she makes this point, it is important to consider how non-users of autonomous vehicles, or automobiles in general, feel about a city's adoption of automated driving. For instance, pedestrians or bikers may feel safer in a city where less collisions may occur due to human mistakes.

In a study by a few researchers interested in pedestrian receptivity, it is found that many people showed increase receptivity towards autonomous vehicles, including those who are urban residents, young, and innovative. Additionally, these individuals believed that fully autonomous vehicles are more likely to improve overall traffic safety, (Deb et al., 2017). Another study shows that since autonomous vehicles tend to be more risk-averse, pedestrians will behave with more impunity, forcing these vehicles toward a pedestrian-oriented outlook, (Millard-Ball, 2016). Lastly, the adoption of autonomous vehicles could potentially increase the need for interaction between drivers and pedestrians. A major obstacle that AVs must face is driving in urban environments with many pedestrians on the road as they must understand pedestrian behavior, which may not be intuitive and can depend on various factors such as demographic of the pedestrian, traffic dynamics, and environmental conditions. A study shows that the biggest factors involved in pedestrian decision making include social factors such as social norms, demographics such as age and gender, and characteristics of the person such as culture and law-compliance, (Rasouli & Tsotsos, 2020). Because of this complexity, it may be beneficial for autonomous vehicles to communicate with pedestrians, rather than the technology predicting what the pedestrian will do. Some information that can be transmitted during this interaction includes messages about the vehicle's current state and belief of its surroundings, (Rasouli & Tsotsos, 2020). Drivers of manually-driven cars usually use nonverbal cues such as vehicle

speed, eye gaze, and hand gestures to convey their intent and communicate awareness towards pedestrians. However, autonomous vehicle drivers may be distracted or absent, leaving pedestrians with little idea of the intent from the vehicle. Researchers have conducted an investigation around the usefulness of interfaces that can explicitly communicate awareness and intent of autonomous vehicle pedestrians, especially focusing on crosswalk situations, (Mahadevan, Somanath, & Sharlin, 2018). Therefore, the adoption of this new technology can potentially revolutionize the way non-users and users of automobiles interact with each other in the future. Furthermore, the relationship between non-users and the technology itself could get better. For instance, Wyatt's feeling of threat to her well-being could be lessened if she had a clearer idea of what the intent of a vehicle was and if this intent was always communicated through an interface.

The relationship between cars and users

As mentioned before, the relationship between cars and users can change with the shift to autonomous vehicles due to the increased workload consumers can take on when driving. This can potentially cause the user to favor traveling more than before, and can even allow them to consider their car as their sanctuary, (Bissell, Birtchnell, Elliott, & Hsu, 2018). When interviewing a few candidates, many noted that while they drive their current manually-driven cars, they reflect on random thoughts, listen to music or podcasts, or talk to their passengers. With autonomous vehicles, people may not be forced to only do these things while driving, but can explore a wider range of options for activities to do, thereby changing the relationship with their vehicle. Researchers also say that autonomous vehicles will end up affecting people's autonomy by controlling the way they drive, (Glancy, 2012). Users of manually-driven cars have full freedom and control of their car when travelling, whereas autonomous vehicles take this job

away from them. In this scenario, not only will users of this technology become more dependent on automated driving, they will also treat their car as a separate technological device that merely completes a task for them. In addition, drivers may lose their authority over their car in multiple situations. One such instance occurs when a driver may want to quickly change course on a whim, which may not be easy to do with an autonomous vehicle that they do not have full control over at every point in time.

Another important aspect to consider is complications between privacy and autonomous vehicles, since personal information can be extracted as people use the technology. Since artificial intelligence is taking the place of human driving, the technology must determine choices based on the individual on a personal level. When this technology replaces a driver in a driverless car, the systems will rely on different data sources to assess the driving environment and take control of the vehicle, (Glancy, 2012). In situations where data like this is extracted, it can be unknown if the data will be transmitted beyond the vehicle. If a user begins to worry about privacy issues between them and their car, that is another potential way individuals' relationship with their vehicles can shift.

When interviewing drivers, 50% of people chose to drive an autonomous vehicle while the other 50% preferred to keep their manually driven cars. Another study has shown that 44% of surveyors decided to remain in regular vehicles, rather than adopting an autonomous vehicle, (Haboucha, Ishaq, & Shiftan, 2017). These results show that there are still hesitations in shifting to automated driving for some, so the relationship change between drivers and their vehicles cannot be identically conclusive for all users.

A pedestrian's perception towards cars

In general, most of the people I interviewed indicated that as a pedestrian, they do not trust manually-driven cars. For instance, when crossing an intersection, 80% of the interviewees indicated that they would wait for the car to fully stop before proceeding, whereas the other 20% suggested that they trust the cars to stop for them. However, 100% of the people I interviewed indicated that their opinion changes when the car is an autonomous vehicle, and that they trust the software of an AV to stop for a pedestrian more than a human. Other research also tends to show that city residents believe the rise of autonomous vehicles will result in a safer area for pedestrians, (Deb et al., 2017). This study also presented that pedestrians may act with more impunity because of this safer feeling, also reflecting the thoughts of those who I interviewed. Because of this potential risk, many researchers have investigated the possibility of creating a system to allow an autonomous vehicle to interact with pedestrians. Since the shift to autonomous vehicles would necessitate pedestrians to find cues from the vehicle itself rather than a driver, one study completed a VR experiment to observe the perspective of pedestrians in different scenarios, (Hudson, Deb, Carruth, Mcginley, & Frey, 2018). Investigations like these are extremely valuable when a significant new technology is being adopted into a society, as pedestrians now use nonverbal cues from drivers to communicate with them – something that will probably not occur with automated driving. Another study assessed the interactions between pedestrians and autonomous vehicles with the presence of an external human-machine interface (HMI) that displayed the vehicle's intentions, (Burns, Oliveira, Thomas, Iyer, & Birrell, 2019). A very important insight that this study highlights is the fact that bi-directional communication with a driver is no longer possible, and suggestions for future HMI concepts that can alleviate the

issue. The adoption of autonomous vehicles does raise this important concern, and clearly demonstrates that the perception of pedestrians can change drastically with the new technology.

Potential challenges cities must overcome

So far, we have discussed the new relationships and perceptions that form among the city residents in an area where autonomous vehicles emerge. However, the cities themselves will also change drastically, resulting in new challenges the area must overcome to fully adjust to the adoption of the new technology. When surveying individuals, all of them indicated that society would be very different if all the cars on the road were autonomous rather than manually driven. Specifically, all of them agreed that there would be different traffic patterns, varied methods of parking, and fewer car accidents. One individual noted that these three things would be more systematic and organized, as software from autonomous vehicles is likely to be more accurate and methodical. They mentioned that traffic would be more consistent as vehicles will follow the correct speed limit, reducing the likelihood of traffic jams. One study agreed with this individual when performing simulations of autonomous vehicles in traffic, suggesting that this technology can improve string stability and prevent shockwave formation, (Talebpour & Mahmassani, 2016). In other words, autonomous vehicles can respond faster to accidents or any other unusual activity in comparison to humans, because of the real-time information the car extracts. Some people I interviewed also discussed that autonomous vehicles will probably follow the same algorithm for parking, resulting in a more organized parking lot. In an article describing parking autonomous vehicles, researchers mentioned that autonomous vehicles can select at least one parking area that is available based on a defined set of parking criteria, (Zhang, Guhathakurta, Fang, & Zhang, 2015). If this algorithm is similar for all cars as the interviewees considered, parking lots could definitely be more structured.

Based on the results from the surveys, interviews, and studies mentioned, it seems that the city will vary significantly when all cars on the road will be autonomous, resulting in variations that the city must adjust to. Police that monitor traffic may have to take a different route in finding those who may be breaking laws on the road. As autonomous vehicles can favor car travel more, parking can increase causing a potential need for larger parking lots. Conversely, a study suggests that autonomous vehicles will lead to travels with a larger number of passengers, resulting in a reduced demand for parking, (Zhang, Guhathakurta, Fang, & Zhang, 2015). If this is the case, the city may need to worry about a wastage space of current parking lots. Furthermore, parking lots in the future can be revamped so that more cars can fit in a smaller space. One study considers that future car-parks for autonomous vehicles can have multiple rows of vehicles stacked behind another with a system of vehicle relocation to take the cars out, (Nourinejad, Bahrami, & Roorda, 2018). They suggested that these "car-parks" can decrease the need for parking space by an average of 62% and even a potential maximum of 87%. Therefore, the refactoring of parking spaces remains a challenge that a city must face with the adoption of the technology.

Conclusion

This paper was meant to discuss the ways in which a society can change with the adoption of autonomous vehicles. When a technology like this becomes integrated into a city, many factors can alter, such as the relationship between drivers and their cars, the perception of a pedestrian towards cars on the road, and the new challenges the city must face as a whole. Through interviews and surveys I have conducted, and past research, it can be highlighted that there are a multitude of changes society can go through as residents begin to use autonomous cars.

In summary, the relationship between drivers and their cars can become entirely different when a person can commit to varied activities when travelling. This can shift the perspective of travelling for a driver and allow them to view their car as a place of privatism rather than just a vehicle they can use to travel from one place to another. Additionally, a user's autonomy will get taken away as a vehicle takes control over the drive, also shifting the user's perspective towards their car. Not only do users of the vehicle get affected, but non-users such as pedestrians must go through a significant adjustment as well. Pedestrians could potentially trust cars more, however, the bi-directional communication present today with drivers and pedestrians will never be the same. Finally, cities must make many adjustments to the arrival of autonomous vehicles because of the variation in traffic patterns and parking.

Autonomous vehicles have the power to change society in three main ways: the shift in relationship between drivers and their vehicles, the pedestrians change in perception towards cars, and new challenges cities may need to overcome with the adoption of the technology. It's incredibly important to analyze the new changes in a society with autonomous vehicles, especially since their arrival is quite inevitable. Various companies and cities such as Waymo in Phoenix, Toyota in Woven City, and Apple in Cupertino are competing to implement autonomous vehicles in the upcoming future and bring it to their city residents, (Matthews, 2020), highlighting that the changes described in this paper will soon become a reality everybody must face.

References

Berggren, C. C. (2020). The Top 10 Benefits of Public Transportation. Retrieved October 19, 2020, from https://www.smartcitiesdive.com/ex/sustainablecitiescollective/top-10-benefits-public-transportation/1063096/

Bissell, D., Birtchnell, T., Elliott, A., & Hsu, E. L. (2018). Autonomous automobilities: The social impacts of driverless vehicles. *Current Sociology, 68*(1), 116-134. doi:10.1177/0011392118816743

Burns, C. G., Oliveira, L., Thomas, P., Iyer, S., & Birrell, S. (2019). Pedestrian Decision-Making Responses to External Human-Machine Interface Designs for Autonomous Vehicles. *2019 IEEE Intelligent Vehicles Symposium (IV)*. doi:10.1109/ivs.2019.8814030

Mahadevan, K., Somanath, S., & Sharlin, E. (2018). Communicating Awareness and Intent in Autonomous Vehicle-Pedestrian Interaction. *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems - CHI '18*. doi:10.1145/3173574.3174003

Deb, S., Strawderman, L., Carruth, D. W., Dubien, J., Smith, B., & Garrison, T. M. (2017). Development and validation of a questionnaire to assess pedestrian receptivity toward fully autonomous vehicles. *Transportation Research Part C: Emerging Technologies, 84*, 178-195. doi:10.1016/j.trc.2017.08.029

Definitions. (2020, April 15). Definitions for technological momentum. Retrieved April 22, 2020, from https://www.definitions.net/definition/technological+momentum

Glancy, D. J. (2012). Privacy in Autonomous Vehicles. *Santa Clara Law Review, 52*(4), 1171-1239.

Haboucha, C. J., Ishaq, R., & Shiftan, Y. (2017). User preferences regarding autonomous vehicles. *Transportation Research Part C: Emerging Technologies, 78*, 37-49. doi:10.1016/j.trc.2017.01.010

Hudson, C. R., Deb, S., Carruth, D. W., Mcginley, J., & Frey, D. (2018). Pedestrian Perception of Autonomous Vehicles with External Interacting Features. *Advances in Intelligent Systems and Computing Advances in Human Factors and Systems Interaction,* 33-39. doi:10.1007/978-3-319-94334-3_5

Maciag, Mike. (2015, February). Why Car-Free Cities Aren't Right Around the Corner. Retrieved October 19, 2020, from https://www.governing.com/topics/urban/gov-car-free-cities.html

Matthews, K. (2020, June 04). The 4 cities competing to fully implement autonomous vehicles. Retrieved October 19, 2020, from https://iot.eetimes.com/the-4-cities-competing-to-fully-implement-autonomous-vehicles/

Millard-Ball, A. (2016). Pedestrians, Autonomous Vehicles, and Cities. *Journal of Planning Education and Research,38*(1), 6-12. doi:10.1177/0739456x16675674

Nourinejad, M., Bahrami, S., & Roorda, M. J. (2018). Designing parking facilities for autonomous vehicles. *Transportation Research Part B: Methodological, 109*, 110-127. doi:10.1016/j.trb.2017.12.017

Oliver, M. (2011). Technological determinism in educational technology research: Some alternative ways of thinking about the relationship between learning and technology. *Journal of Computer Assisted Learning, 27*(5), 373-384. doi:10.1111/j.1365-2729.2011.00406.x

Ondruš, J., Kolla, E., Vertaľ, P., & Šarić, Ž. (2020). How Do Autonomous Cars Work? *Transportation Research Procedia,44*, 226-233. doi:10.1016/j.trpro.2020.02.049

Povlock, Paul. (2016). “Environmental Ethics and The Electric Power Grid: A Case for Technological Momentum.” *Ph.D. Dissertations (Open Access)*: 3-10

Rasouli, A., & Tsotsos, J. K. (2020). Autonomous Vehicles That Interact With Pedestrians: A Survey of Theory and Practice. *IEEE Transactions on Intelligent Transportation Systems, 21*(3), 900-918. doi:10.1109/tits.2019.2901817

Talebpour, A., & Mahmassani, H. S. (2016). Influence of connected and autonomous vehicles on traffic flow stability and throughput. *Transportation Research Part C: Emerging Technologies, 71*, 143-163. doi:10.1016/j.trc.2016.07.007

Tian, Y., Pei, K., Jana, S., & Ray, B. (2018). DeepTest: Automated Testing of Deep-Neural-Network-driven Autonomous Cars. *Proceedings of the 40th International Conference on Software Engineering*. doi:10.1145/3180155.3180220

Wikipedia. (2018, October 17). Technological momentum. Retrieved April 22, 2020, from https://en.wikipedia.org/wiki/Technological_momentum

What is an Autonomous Vehicle? (2020). Retrieved October 19, 2020, from https://www.twi-global.com/technical-knowledge/faqs/what-is-an-autonomous-vehicle

Wyatt, Sally. (2003). “Non-Users Also Matter: The Construction of Users and Non-Users of the Internet.” *MIT Press:* 67-75

Zhang, W., Guhathakurta, S., Fang, J., & Zhang, G. (2015). Exploring the impact of shared autonomous vehicles on urban parking demand: An agent-based simulation approach. *Sustainable Cities and Society, 19*, 34-45. doi:10.1016/j.scs.2015.07.006