

Human-computer trust in navigation systems: Google maps vs Waze

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Abstract

This study investigates users' trust and reliance toward navigation systems. Forty participants participated in the experiment comparing Google Maps and Waze that have different mechanisms (data-based vs community-based). Our findings revealed that users had higher trust in Waze than Google Maps, due to the higher degree of flexibility in information sharing. Furthermore, we found that users tend to utilize the navigation application used, implying that trust in navigation system is highly associated with trustors' prior experience and familiarity. Google Maps users changed their reliance on Google Maps to Waze upon experiencing Waze features. This study offers several implications that system designers: (i) must ensure that the system's transparency is maintained, (ii) should profoundly analyze possible interaction between users and computer agents, (iii) should ensure that certain safety conditions are maintained despite the freedom of information sharing provided by the computer agent.

Keywords: trust, navigation, google maps, waze

1. Introduction

The use of navigation system has further expanded, not only to support drivers while driving in unfamiliar locations [1], but also to do route-check prior to driving to avoid traffic congestion. This feature is definitely important given the increase in worldwide road traffic density that is forecasted to be double in 2040 as compared to that in 2015 [2]. This increase will lead to tremendous traffic congestion [3] that can already be observed nowadays.

A navigation system allows drivers to check the routes to determine the fastest or easiest route among several route alternatives provided by the system. The navigation system relies on Global Positioning System (GPS) technology, a system that consists of configuration of several operational satellites in six earth's orbital planes with certain elevation angle to provide the positioning information [4]. The navigation system has also readily been available as an application in a smart phone.

Google Maps and Waze are the most popular mobile applications providing navigation service [5]. Google Maps is a web-based mapping service that is developed by Google. This service provides route map, 360° panoramic view, traffic condition, and route planning. This satellite-based navigation system utilizes cell-tower. Triangulation principle of several cell tower is applied in addition to the GPS position information to provide interactive service [6]. Google Maps has also added several features such as traffic updates and interesting places (e.g. restaurants and other landmarks).

Waze, on the other hand, is a navigation application that supplies information traffic and route conditions (e.g. route hazards, accidents, traffic congestion) real-time. Waze works based-on crowdsourcing principle where the traffic information is collected from other Waze users [7]. The crowdsourcing-based information is processed by Waze to provide several shortest route alternatives. Users can work together to complete their tasks and they will obtain both tangible and intangible incentives [8] and in this case, the intangible incentive is the shortest route.

Both Google Maps and Waze provide positioning information and involve interaction between the system (computer) and the user. In human-computer interaction, trust level in the system, or so-called Human-Computer Trust (HCT) is essential since it will influence the use of information provided by the system [9] and affect effective interaction between the user and the computer (information agent) in a complex system [10].

On top of that, another interesting line associated to trust is a possible difference when users rely on information generated by computer versus human-being. Dzindolet, et. al. [11] found a significant bias in the trust toward automation in complex systems. In their research, users perceived that automation was more reliable than human. However, the higher perceived reliability of the automation did not go linear with the use of the automation. The users still tended to have higher self-reliance despite the higher perceived reliability in the automation system.

Trust in technology is an 'under-explored area' in prior research [12]. In general, however, more research related to

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HCT in navigation system is needed [13]. Research related to trust in navigation system has limited to the effect of voice on the trust in navigation system [14] and the comparison study between Open Street Map, Bing Map, and Google Maps [15] that actually had similar work mechanisms. Noerkaisar, et al. [16] and Afonso, et al. [17] merely conducted a survey regarding the awareness and reputation of Waze. No empirical research has been conducted to investigate trust in crowdsourcing-based navigation system and compare it with the common navigation system (i.e. Google Maps). Given these facts, there is a need to understand how information delivery would affect trust in and dependence on navigation systems. Therefore, this research is conducted to assess and investigate HCT level in Google Maps and Waze as well as the decisions toward both systems.

Several hypotheses were generated and tested in this study. First, Waze adopts information crowdsourcing principle and allows users to directly share information to other users. In this community-based mechanism [18], users can rely on other users' feedback, while in data-based mechanism the navigation information is mainly provided through satellite surveillance data. Based on Dzindolet's finding that human tends to have higher reliance on human than machine agent, it was hypothesized that HCT in Waze (community-based app) will be higher than Google Maps (data-based app) (H1). We also further hypothesized that prior experience in using a certain system would affect user dependence toward the system [10,19]. In the context of navigation system in this study, Google Maps users would prefer Google Maps and Waze users would prefer Waze (H2). Lastly, there would be a possibility that users would change their preference upon experiencing another navigation system. Given the expected higher trust in Waze, we hypothesized that Google Maps users would change their preference upon utilizing crowdsourcing-based platform (i.e. Waze) (H3).

2. Materials and Methods

2.1. Participants

The participants in this research were recruited using multiphase sampling. First, a questionnaire was randomly disseminated to obtain appropriate participants for the experiment. The participants who have used either Google Maps or Waze application for at least 1 year with the average frequency of use twice weekly were eventually recruited for the experiment. Forty persons satisfying the aforementioned criteria participated in the research. The forty participants were divided into two groups, each consisting of twenty Google Maps users aged 20 to 24 years old (10 males, M = 21,7 years old SD = 1.1 years old) and Waze users aged 20 to 23 years old (10 males, M = 21.6 years old, SD = 0.9 years old), respectively.

2.2. Apparatus

Two questionnaires were provided for participants. The first questionnaire was disseminated to obtain appropriate participants with the abovementioned criteria. The second questionnaire aimed to assess Human-Computer Trust level in

navigation system. This HCT questionnaire adopted human-machine questionnaire developed by Jian, et al. [20] since Jian's questionnaire could successfully measure trust and distrust as two opposite ends on a single continuum. Google Maps and Waze applications, as shown in Figure 1 and 2, were also provided to the participants during the experiment. The data obtained during the experiment were analyzed using Ms. Excel, SPSS, and JASP software.

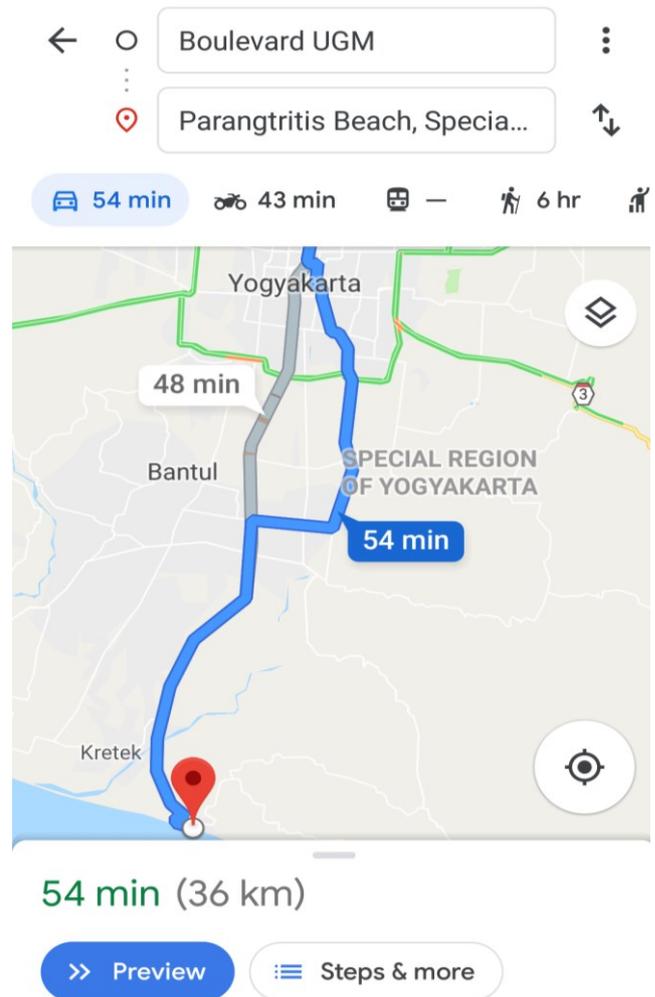


Fig 1. Google maps application

2.3. Design

A mixed-design with two factors was adopted (Table 1). The first factor, navigation application, was a within-subjects factor with two levels: Google Maps and Waze. The second factor, application user, was a between-subjects factor with also two levels: Google Maps and Waze users.

Table 1. Experimental design

Users	Apps	
	Google Maps	Waze
Google Maps	X	X
Waze	X	X

The dependent variables were user trust, user decision, and proportion of application selection. User trust was assessed using HCT questionnaire. User decision and the proportion of application selection were obtained from user preference

toward both navigation systems during the experiment with three route scenarios.

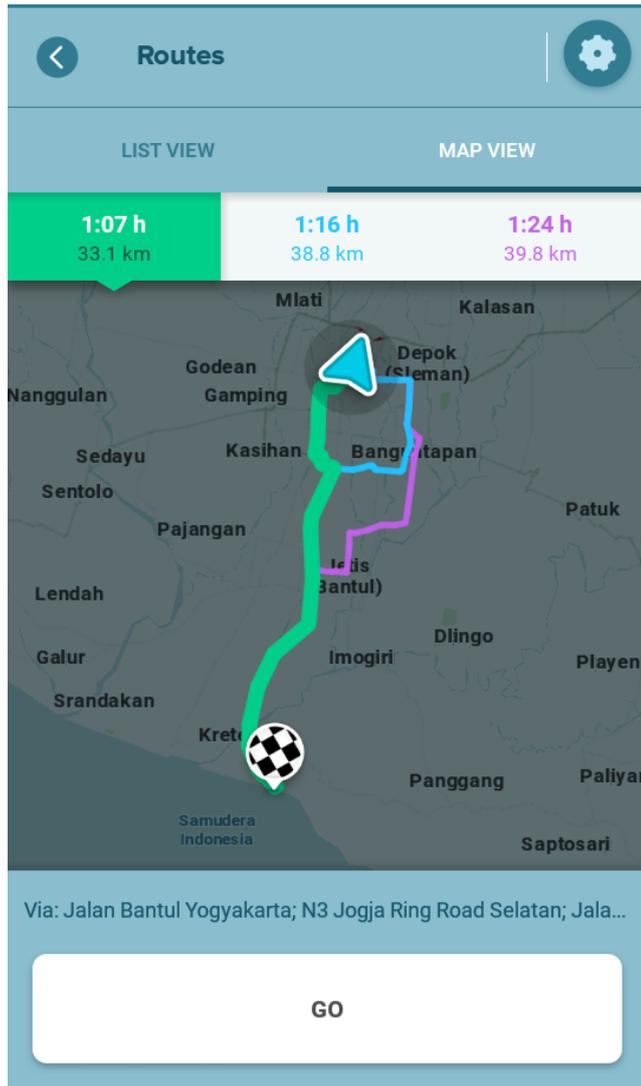


Fig 2. Waze application

The scenarios were generated considering various distances (short, medium, and long) and destination familiarity. There were also at least two route options offered by each navigation system from the similar starting point. The first route scenario was from Universitas Gadjah Mada to Malioboro, a famous tourist shopping destination in Yogyakarta. The second scenario was the route from Universitas Gadjah Mada to Giwangan Bus Station. The third scenario was the route from Universitas Gadjah Mada to Parangtritis Beach.

2.4. Task and Procedure

In the initial stage, a preliminary questionnaire was distributed to potential participants to hire appropriate participants satisfying the criteria for this study. Next, both groups (Google Maps and Waze users) were requested to rate their trust in their navigation system by filling in the HCT questionnaire. Google Maps group rated their trust in Google Maps application and so did Waze group.

During the experiment session, each participant was provided with both Google Maps and Waze for each route scenario. All route permutations in the three route scenarios

were shown to the participants. They were then requested to rate their propensity toward either navigation system. The rating format was provided in a 7-Likert Scale with Google Maps and Waze as the option for the most right and left end of the scale, respectively.

2.5. Statistical Analysis

An independent t-test was performed to analyze HCT between Google Maps and Waze users as well as the reliance toward either system in all three scenarios. Homogeneity and normality assumptions were checked prior to the test. Mann-Whitney test was performed in case of a violation of the assumptions. A proportion analysis using Chi-Square test was also performed to examine participants' consistency across the two navigation options.

3. Results

3.1. Human-Computer Trust Rating

In general, both Google Maps and Waze users have high trust toward their navigation applications, as indicated by the overall HCT rating ($M = 5.48$). Since the normality assumption was violated for Google Maps data, a non-parametric, Mann-Whitney test was conducted and rendered a significant value, $U(38) = 59.50$, $p = <0.01$. This finding shows that the users' trust in Waze was higher than their trust in Google Maps, as shown in Figure 3, thus supporting H1.

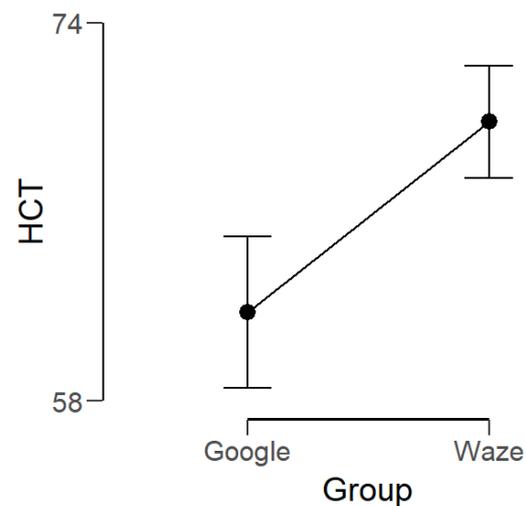


Fig 3. Trust rating across both systems

3.2. User Dependence

User dependence on either navigation system was obtained from the experiment for all the three scenarios. In each scenario, there were similar number of route alternatives as suggested by both applications (Google Maps and Waze). Each participant was requested to rate from 1 to 7 showing their tendency toward each application. Score 1 and 7 indicate the preference toward Google Maps and Waze, respectively.

First Scenario - Boulevard of Universitas Gadjah Mada to Malioboro. The effect of experience on user dependence was significant, $t(38) = 9.10$, $p = <0.01$. This result revealed that

Google Maps users indeed more preferred Google Maps and Waze users also more preferred Waze as indicated by the lower value and higher value for Google Maps and Waze, respectively (Figure 4).

Second Scenario - Boulevard of Universitas Gadjah Mada to Giwangan Bus Station. Similar to the first scenario, the effect of experience on user dependence was also significant, $t(38) = 7.70, p < 0.01$. This result shows similar finding as the first scenario (Figure 5).

Third Scenario - Boulevard of Universitas Gadjah Mada to Parangtritis Beach. Similar to the first and second scenarios, the effect of experience on user dependence was also significant, $t(38) = 9.10, p < 0.01$. This result shows similar finding as the first and scenarios (Figure 6).

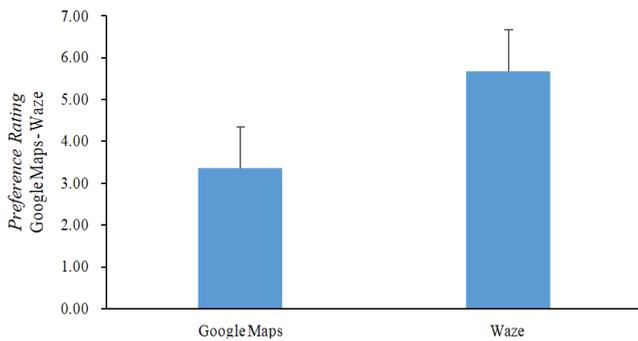


Fig 4. User dependence in scenario 1

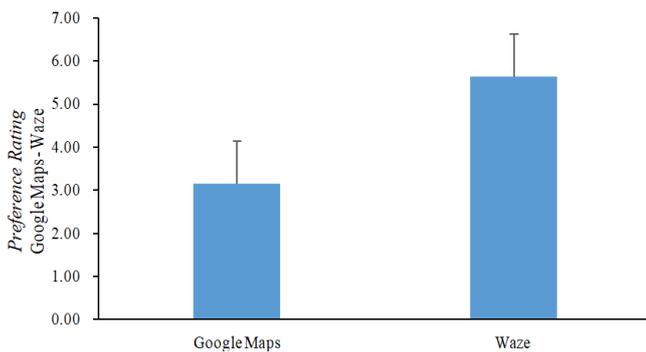


Fig 5. User dependence in scenario 2

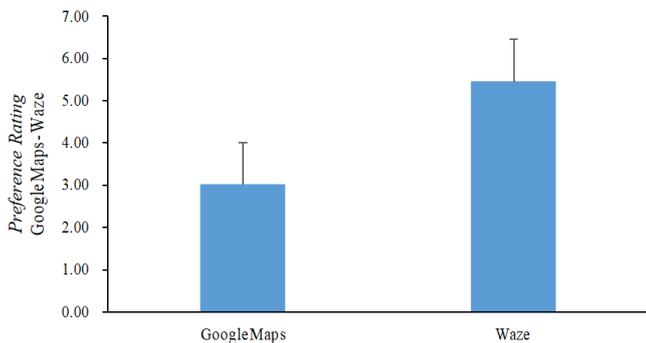


Fig 6. User dependence in scenario 3

3.3. Proportion of User Preference

To test for association between navigation system users and their reliance upon the system across scenarios, a Chi-Square association test was conducted. There was a significant dependency, $\chi^2(1, N=38) = 17.14, p < 0.01$. Investigation of users' reliance revealed changes in the Waze utilization by

Google Maps users as shown in Figure 7. It can be inferred that Waze users are consistent toward using Waze across scenarios as indicated by 100% reliance upon Waze. On the hand, however, Google Maps users showed their inconsistent reliance upon Google Maps. As many as 40% of Google Maps users changed their preference to Waze after being introduced to Waze.

4. Results and Discussion

The current study addressed the gaps found in human-computer interaction, particularly regarding the trust issue that is a very important factor defining appropriate reliance [10] in the context of navigation system. The rapid development of GPS technology allows the advancement of mobile navigation applications.

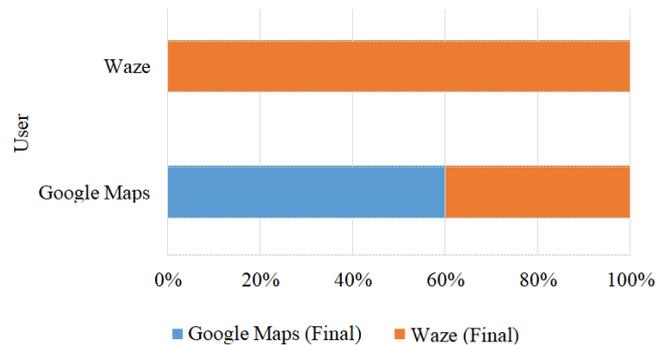


Fig 7. Proportion of application selection by users

Google Maps and Waze are the two most popular applications for navigation. Google Live Traffic was added to Google Maps in 2007 and has been used to support the optimization of route calculation for the sake of avoiding traffic jam in 2011 [21]. Floating Car Data (FCD) of smartphones are used in Waze to generate real-time traffic information. Users are allowed to report road hazards such as accidents and speed traps, share traffic jams information, and add new roads directly through the Waze application. Via a prior registration upon using the application, a Waze user will be given a unique ID and cookie that will be the identifier during information dissemination [21].

Given the essential information sharing between machine-human as well as human-human through a navigation aid, trust in the navigation aid becomes increasingly critical. Particularly, this will influence how the user acts on or relies upon the suggestions or decisions generated by the aid [22].

In our study, we found that Waze users trust their application higher than Google Maps users do in Google Maps. Waze aims to support for an effective traffic by allowing users to interact and inform real-time traffic conditions, thereby promoting collaboration and helping other users [17]. Given the fact that Waze gives its users higher degree of flexibility in information sharing with other users, this is in-line with Dzindolet's [11] finding that human indeed relies more on human than machine agent.

Another possible reason for the higher trust observed in Waze users is transparency. The direct information sharing feature that is offered in Waze increases its transparency, thus increasing trust in it. In trust concept, goal reasoning needs to

be clear, that is, the completion of tasks and goals should be known so that the trustor can trust the agent's ability in making decisions toward the goals [23].

The second most important finding about trust in navigation system is that trust is highly associated with trustors' prior experience and familiarity. In our study, we found that users tend to utilize the navigation application that they have used. In our study, Google Maps users tend to choose Google Maps' suggestions and Waze users also tend to rely on Waze across the three scenarios that differ in the distance. This finding was supported by Lee and See [10] who stated that initial experience has a lasting effect on trust. Trust is at cognitive stage of a human-being and reliance is the manifestation of the trust [9]. This, therefore, explains higher reliance toward initially experienced navigation system.

However, the development of human's trust to an agent is extrapolated across several interactions, such that trust might be first built from an initial specific experience, but it is actually based on the generalization of diverse experiences [10]. In this study, we also empirically tested this phenomenon and found a consistent finding in the context of navigation system.

We found that Waze could influence users' reliance. Google Maps' users were observed not to be highly consistent in using Google Maps after being introduced to Waze. They changed their reliance from using Google Maps to using Waze upon experiencing Waze features. Their trust in Google Maps might first be based on their prior experience. However, as experience increases, users produce a feeling for agent's predictability [24].

Predictability in Waze was perceived as higher due to the direct information sharing available in Waze. Bos [25] found that online communications between humans are as effective as face-to-face interactions. In the navigation context, this increases reliance upon the system based on the inputs from other users in any forms. A survey by Noerkaisar [16] showed that commuters had high agreement that Waze is simple to use and guides the way to avoid congestion. Waze also allows users to edit, update maps and provides real-time information. The respondents also implied that Waze follows the trend of technology. Collectively, Waze seems to be taking advantage by being a 'community-based application' [17] where its users are interested in work together to achieve a common and known goal which is the shortest and easiest route.

The findings in this study offer important implications for navigation system designers as well as for the science of human-computer interaction. First, the higher trust in Waze which bases their mechanism on crowdsourcing or community-based application continue to suggest that human indeed have greater reliance upon human agent [11]. Thus, when system designers aim to design a system that incorporates autonomous agent, they must ensure that the system's transparency is maintained. System designers should answer the question on how to frame a goal reasoning process to promote transparency [23].

Second, our finding that a prior experience could determine reliance toward a navigation system suggest that system designers should profoundly analyze possible interaction between users and computer agents. The interactions would accumulate knowledge thus establishing sufficient trust based

on expected value, where users can estimate probabilities of various events given increasing experience [26].

Lastly, community-based systems may be more preferred than fully-autonomous ones. However, this leaves other issues about safety, privacy, and authenticity [21]. The question concerning safety issue remains, how can one ensure that certain safety conditions are maintained despite the freedom of information sharing provided by the computer agent? [23]. Therefore, system designers should carefully classify certain dimensions of trustworthiness that are more applicable in particular circumstances (i.e. more vulnerable tasks or more autonomy and intelligent technology) [27].

5. Conclusion

This study intended to investigate users' trust and reliance toward navigation systems and compare the two most popular navigation applications (i.e. Google Maps and Waze) that have different mechanisms (data-based vs community-based). We also analyzed users' consistency in using navigation system. We conducted the research in two steps. The first step focused on subjective rating and the second step was an experiment based study.

Our findings revealed that users had higher trust in Waze than Google Maps. This was due to the higher degree of flexibility in information sharing between users that is offered in Waze, thus increasing system transparency. Next, we found that users tend to utilize the navigation application that they have used. This implies that trust in navigation system is highly associated with trustors' prior experience and familiarity. Lastly, Google Maps users changed their reliance on Google Maps to Waze upon experiencing Waze features. Users generate a feeling for agent's predictability and change their reliance based on this feature.

The findings, however, should be interpreted and generalized with caution since the data analyzed in this study were mainly collected in Indonesia, particularly in Yogyakarta province. Trust is a multi-faceted construct that is influenced by many factors, such as culture and environment. There should be expanded further studies with greater participation of navigation apps' users in various countries and regions across the globe.

Nevertheless, several implications are offered in this study. First, when system designers aim to design a system that incorporates autonomous agent, they must ensure that the system's transparency is maintained. Second, system designers should profoundly analyze possible interaction between users and computer agents. Third, system designers should ensure that certain safety conditions are maintained despite the freedom of information sharing provided by the computer agent.

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