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Travel distance judgment: an environmental distance information cognitive processing perspective

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Keywords

information, environmental, judgment, perspective, distance, processing, travel, cognitive

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TRAVEL DISTANCE JUDGMENT: AN ENVIRONMENTAL DISTANCE INFORMATION COGNITIVE PROCESSING PERSPECTIVE

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Abstract

A consumer makes travel distance judgment to determine the place to visit. Stores that gain favorable travel distance judgment could gain access to a large volume of customer base. Travel distance judgment is often made with the aid of technologies, such as the mobile location-based service (LBS). In the present research-in-progress, we build on the human's environmental distance information cognitive processing model to propose how the travel distance information and visual geospatial information jointly influence a consumer's travel distance judgment. We posit that the combination of direct-distance travel information and destination visual reachable geospatial information (2D-map) could result in favorable travel distance judgment; likewise, the combination of estimated travel time information and destination visual opaque geospatial information (3D-map) could result in good travel distance judgment. Empirical validations on the propositions are also proposed. The article ends with a discussion on potential implications for research and practice.

Keywords: Distance judgment, Geospatial information, Consumer choice.

1 INTRODUCTION

Travel distance judgment, a consumer's perception and belief about the distance between two endpoints of a route (Montello 2009), is a critical reflection of his/her choice of visiting a place, such as patronizing a store (Witmer & Kline 1998). Scholars have highlighted that an individual's judgment of distance to a store could differ from the actual travel distance (Montello 2009; Raghubir & Krishna 1996). For example, Raghubir and Krishna (1996) found that even if all the stores have the same actual travel distance for a consumer; he/she would choose the store that is perceived to be closest in term of direct distance. It is deduced that by being strategically located, stores could easily gain access to a sizable customer base (Huff 1963).

Due to the technological advancement in location-based service (LBS), a consumer can now leverage on the LBS to automatically compute the travel distance from one point to the other (Bohnenberger, et al. 2002). Elaborately, a consumer can easily leverage on the LBS running in his/her smartphone to find out the location of a store and the relevant geospatial information before making a travel choice. If a consumer could make favorable travel distance judgment of a place (e.g., using the LBS to compute the travel distance to a shopping mall), then there is a high likelihood that he/she would travel to there (Ankomah & Crompton 1992).

The travel distance information and the visual geospatial information are two primary determinants of the travel distance judgment (Grewal, et al. 2012; Kang, et al. 2003; Raghubir & Krishna 1996; Saisa, et al. 1986). The travel distance information provides information to users for estimating the travel distance, such as estimated travel time and direct distance (Saisa, et al. 1986). The visual geospatial information means the available geographical information of the route for estimating the travel distance, such as the map (Irmak, et al. 2011; Oulasvirta, et al. 2009). Some scholars found consumers would use the direct-distance as a salient indicator to estimate the travel distance (Raghubir & Krishna 1996). Whereas other scholars demonstrated that the estimated travel time outperforms the distance measures when judging the travel distance (Kang, et al. 2003). This research seeks to build on the two viewpoints of prior studies to understand how a consumer utilizes the travel related information to make a travel distance judgment. This research-in-progress seeks to answer the following question: *What are the joint impacts of travel distance information and visual geospatial information on the s consumer's travel distance judgment?*

To answer the research question, the present research-in-progress adopts the human's environmental distance information cognitive processing model (Montello 2009). Contextualize in consumers using smartphone devices, we propose that the appropriate display of travel distance information and visual geospatial information could jointly influence the travel distance judgment. Two laboratory experiments will be conducted to validate the hypotheses. Based on the human's environmental distance information cognitive processing model and prior literature, we will focus on the estimated travel time and direct-distance as the travel distance information. Then, we will examine how the changes of visual geospatial information (e.g., smartphone equipped 2D-map and 3D-map) could combine with travel distance information and have joint impact on travel distance judgment.

The findings of the research-in-progress could contribute to both the scholars and practitioners. First, this research-in-progress contributes to the empirical operationalization and validation of the human's environmental distance information cognitive processing model (Montello 2009). It also complements the theoretical details of the information processing for geospatial information from other theoretical foundation, such as accessibility-diagnosticity framework (Menon, et al. 1995). Second, this research-in-progress complements the research gap on how to effectively present the geospatial and travel distance information in terms of the conditional situations (Kang, et al. 2003). Third, this research-in-progress could provide applicable guidelines to practitioners for the best utilization of the travel distance information and visual geospatial information in the business campaign activities.

2 LITERATURE REVIEW

The human's environmental distance information cognitive processing model details the cognitive process of individuals in retrieving, encoding, and utilizing the environmental distance information to estimate the subjective travel distance to a location (Montello 2009). The subjective travel distance refers to the individual's perception and beliefs about the distance between the two endpoints of a route (Thorndyke 1981). It might be different from the objective distance (i.e., the actual distance) between two endpoints of a route (Montello 2009). For example, *ceteris paribus*, an individual may choose to go over to "Store A" which is actually 5 miles away from the current location rather than "Store B" which might be 3 miles away because this individual may perceive the travel to "Store A" to be shorter (Raghubir & Krishna 1996).

The human's environmental distance information cognitive processing model is a conceptual model (Montello 2009). The essential logic of this model contains three steps: First, users would evaluate whether both of the travel distance information and geospatial information are available. If only one of them is available, then the users will rely on the available information to estimate the travel distance.

Second, when all of the travel distance information and geospatial information are available, users will examine whether the estimated travel distance already exists in memory. In the condition of existence of travel distance in memory, users will simply retrieve it from memory. Otherwise, users will process the environmental information further to estimate the travel distance. This will lead to the third step of the processing of the environmental distance information.

In the third step, users first judge whether there is a clear visual presentation of the destination. In the condition of existence of clear visual presentation of the destination, users will rely on direct distance between the two endpoints of the route to estimate the travel distance. In the condition of absence of clear visual presentation, users will use the estimated time/effort heuristics to judge the travel distance.

Guided by the human's environmental distance information cognitive processing model, we review prior literature and seek to empirically operationalize this model. In particular, the operationalization of the environmental distance information is vital (Montello 2009). To estimate the subjective distance to a destination, individuals would leverage on the availability of information, such as the travel distance information and visual geospatial information (Kang, et al. 2003; Kim, et al. 2012; Montello 2009; Raghubir & Krishna 1996).

2.1 Travel Distance Information (Direct-distance and Estimated Travel Time)

The travel distance information typically contains both the direct-distance and estimated travel time (Kim, et al. 2012). The direct-distance refers to the straight distance between the endpoints of a route (Raghubir & Krishna 1996). Raghubir and her colleague (1996) found that when individuals are choosing stores with the same path length (i.e., the physical travel route to the stores) but different direct distance, the store with shortest direct-distance will be selected. In other words, despite the same traveling path distance to the stores, individuals are likely to choose traveling to the store that has the shortest straight distance. This is because estimating the traveling path distance would be cognitively more complex and the easy alternative would be to use direct-distance (i.e., simply draw a straight line between two locations) (Paas, et al. 2003).

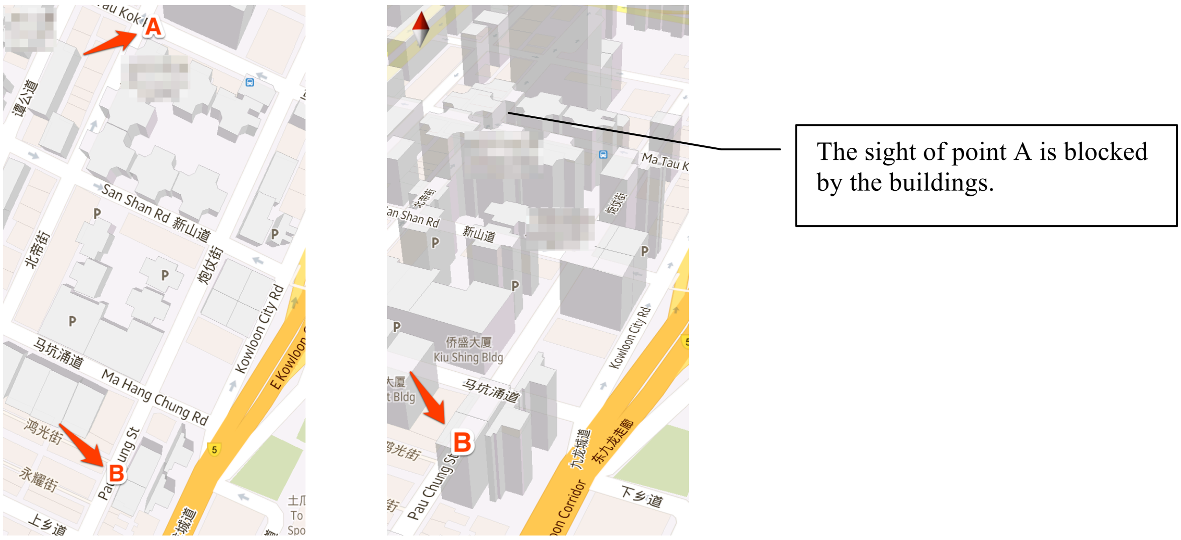
The estimated travel time refers to the expected elapsing time of a travel trip deduced through a travelling means (e.g., 5 minutes by walking from current location to the pharmacy) (Kang, et al. 2003). The estimated travel time is an important information input for the distance judgment because time is a good indication of the cost of an activity (Kim, et al. 2012). For example, when estimating the workload (cost) of paper writing, one usually uses time (e.g., I will use five days to finish writing the paper), rather than the number of words (e.g., the paper will consist of 9,867 words). Scholars found that people are prone to heuristically use amount of time needed to judge the travel distance, rather than other distance measurements (e.g., distance presented in meters) (Grewal, et al. 2012; Kang, et al. 2003).

2.2 Visual Geospatial Information (2D- and 3D-map)

The visual geospatial information is typically presented in the form of digital map (Kulju & Kaasinen 2002). A digital map could be manifested in either 2D-map or 3D-map (Oulasvirta, et al. 2009). The 2D-map and 3D-map differ in terms of viewing angles, destination visibility, and measurement (Wickens, et al. 2000).

The 2D-map (two-dimensional) provides an overview of the surroundings and presents the general overview of the route with no visual elevation (Oulasvirta, et al. 2009). It usually has the crow-flying angle to oversee the selected area. Thus, the 2D-map affords a decent destination visibility (Wickens, et al. 2000). For example, smartphone users could identify the location of point A and point B in the 2D-map and their relative positions (see Figure 1 on a sample 2D-map). The 2D-map also has fewer measurement biases than the 3D-map, such as the straight line deformation bias caused by perspective illusion (e.g., Ponzo illusion) in the 3D-map (Kulju & Kaasinen 2002). With the planimetric nature of the 2D-map, smartphone users could estimate the approximate distance between two endpoints. Hence, the 2D-map is capable for the abstract rendering of the geospatial information of a route (Oulasvirta, et al. 2009).

Contrary to the 2D-map, the 3D-map (three-dimensional) is more advanced in presenting the volumetric concepts, which is an important dimension of geospatial information (Oulasvirta, et al. 2009). The 3D-map could provide the exocentric view of the route (Wickens, et al. 2000). Therefore, it brings mobile users rich and realistic visual details of the geospatial information of a route that is closer to the physical world. Hence, the 3D-map could facilitate the smartphone users' decision to travel (Aggarwal & Mcgill 2007). However, the 3D-map has poor performance on the destination visibility and the measurement biases (Wickens, et al. 2000). In a 3D-map, the building objects often block the sight of the users (Kulju & Kaasinen 2002). Smartphone users could not find the precise destination location of a route in 3D-map (Wickens, et al. 2000). Moreover, with the Ponzo illusion effect, the 3D-map will have greater measurement biases than the 2D-map (Krishna, et al. 2008). The length of a route in 3D-map could have greater deviation than the same route in 2D-map. In this regard, users could have difficulties in judging the travel distance when using the 3D-map (Oulasvirta, et al. 2009). An example of 3D-map is showed in Figure 1 (right-hand side).



2D-map 3D-map

Figure 1. Pictorial exemplifications of 2D-map and 3D-map on a smartphone device

3 RESEARCH MODEL AND HYPOTHESES DEVELOPMENT

Anchoring on the human's environmental distance information cognitive processing model, we propose the overarching thesis (see Figure 2): *The display of travel distance information and visual geospatial information could jointly influence the smartphone users' travel distance perception and intention to travel. The combination of direct-distance travel information and destination visual reachable geospatial information (2D-map) could result in better travel distance perception and intention to travel; likewise, the combination of estimated travel time information and destination visual opaque geospatial information (3D-map) could result in better travel distance perception and intention to travel.*

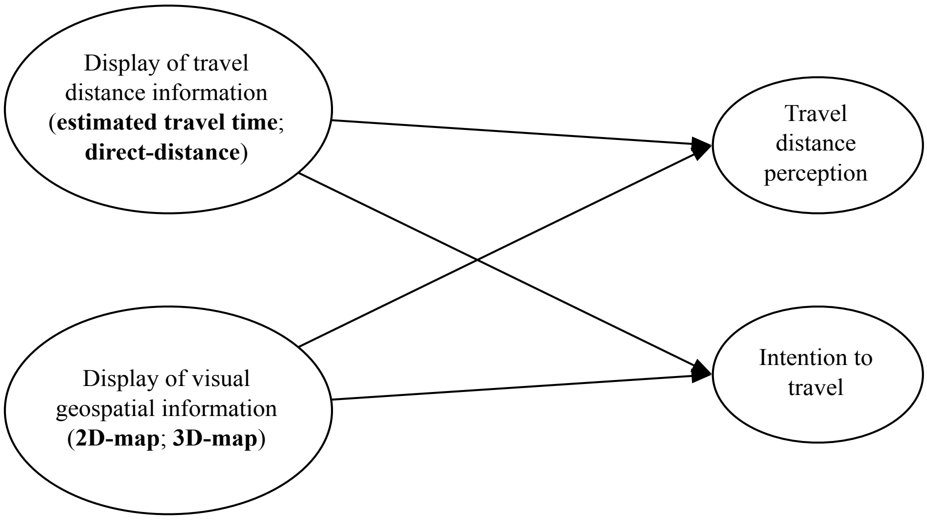


Figure 2. The conceptual research model

In the present research-in-progress, the display of travel information will be manifested by the direct-distance information and the estimated travel time information, respectively (see Figure 2). The display of visual geospatial information will be manipulated as the 2D-map and 3D-map on a smartphone. For the dependent variables measurement, we will use the travel distance perception and intention to travel. The meaning of travel distance perception is in line with the definition of subjective travel distance (Montello 2009). The intention to travel represents the specific purpose of performing the travel. The higher intention the users have for the travelling, the higher likelihood the users will go for the trip (Guinea & Markus 2009).

Display travel distance information (main effect): In the sole availability of travel distance information, users would use this information to estimate the travel distance (Montello 2009). In this situation, smartphone users would experience uncertainty of the geographical information between two endpoints (e.g., how many alternative routes) (Oleksiak, et al. 2010). In this regard, the estimated travel time becomes the more accessible information to evaluate the travel distance than the direct-distance information (Kang, et al. 2003). The "accessible" refers to the ease that information will be retrieved from memory (Tybout, et al. 2005). This is because time is an easily retrievable measurement for estimating the cost of the travel, especially when other possible measurements (e.g., physical walking distance) are not available, or difficult to calculate (Kang, et al. 2003; Menon & Raghubir 2003). As a result, the favourable travel distance perception and intention to travel could be achieved. Thus, we posit:

H1a: *The display of estimated travel time information would result in shorter perceived travel distance than the display of direct-distance information.*

H1b: *The display of estimated travel time information would result in higher intention to travel than the display of direct-distance information.*

Display visual geospatial information (main effect): In the sole availability of visual geospatial information, smartphone users would have to rely visual geospatial information to estimate the travel distance (Montello 2009). Comparing the 2D-map display and 3D-map display on the smartphone, the latter one could provide more vivid geospatial information to users (Kulju & Kaasinen 2002). By matching the perceptual schema of the travel and physical environment of the route, the 3D-map display could immerge users into the presence of the route. Thus, it enhances the scenographic recreation of the travel (Foley & Cohen 1984). In addition, with the consideration the effects of Ponzo illusion (i.e., users' overestimation of the differences in size of two identically-sized lines when placed over parallel lines that seem to converge as they recede into the distance[1]), smartphone users would

[1] Reference source: http://psychology.about.com/od/sensationandperception/ig/Optical-Illusions/The-Ponzo-Illusion.htm

perceive the length of a route in the 3D-map is shorter than in 2D-map on the smartphone (Krishna, et al. 2008). Hence, the 3D-map display will generate a more favorable travel distance perception and higher intention to travel. Thus, we posit:

H2a: *The display of 3D-map would result in shorter perceived travel distance than the display of 2D-map.*

H2b: *The display of 3D-map would result in higher intention to travel than the display of 2D-map.*

In the 2D-map display condition (joint effect): Regardless the condition in which the estimated travel distance has already existed in users' memory, when presenting both the travel distance information and the visual geospatial information, smartphone users would utilize them jointly to estimate the travel distance (Montello 2009). In the 2D-map display condition, the 2D-map on the smartphone could clearly present the endpoints of a route (see Figure 1, 2D-map). With the explicit destination visibility (e.g., visual reachable geospatial information), users could identify several routes from the start point to the destination (Wickens, et al. 2000). When presenting the estimated travel time with the 2D-map, even though the time is the accessible information for travel decision, users do not know the estimated travel time is compatible for which route (Kang, et al. 2003). Thus, users would encounter difficulties on associating the estimated travel time to the alternative routes (Saisa, et al. 1986). In this regard, the estimated travel time will bring uncertainty to the perception of travel distance. Compared with estimated travel time, the direct-distance could explicitly indicate the shortest distance between the endpoints. Coupled with the good destination visibility of 2D-map, the users could identify the optimal route for the travel (Thorndyke & Hayes-Roth 1982). As a result, the direct-distance measure becomes more salient for representing the travel distance of a route than the estimated travel time. Thus, we posit:

H3a: *In the case of presenting 2D-map on the smartphone, the display of estimated travel time information would result in longer perceived travel distance than the display of direct-distance information.*

H3b: *In the case of presenting 2D-map on the smartphone, the display of estimated travel time information would result in lower intention to travel than the display of direct-distance information.*

Under the 3D-map display condition (joint effect): The 3D-map display on a smartphone device might not be able to clearly present (or mark) the destination and/or the possible alternative routes (e.g., visual opaque geospatial information) (Wickens, et al. 2000). In this regard, the 3D-map might not be able to alleviate the uncertainty of the geospatial information (Wickens, et al. 2000). In addition, when presenting the direct-distance information, there would be cognitive distance measurement dissonance between the actual direct-distance information and the route distance in 3D-map in terms of the effects of Ponzo illusion (Krishna, et al. 2008). As a result, smartphone users would have to spend additional cognitive effort to adjust the direct-distance information with the presence of the route in 3D-map display (Witt, et al. 2004). Contrary to the direct-distance information, the estimated travel time could adequately indicate the holistic travel expenditure to users and then reducing excessive cognitive efforts (Coupey 1994). Even though users do not know which route in the 3D-map is compatible with the estimated travel time, users are free from spending extra cognitive effort to anticipate the travel distance in the 3D-map display context (Garbarino & Edell 1997). For example, all other things being equal, the distance for 10 minutes walk is heuristically longer than the 2 minutes walk. As a result, the provision of estimated travel time is more appropriate to estimate the travel distance than the direct-distance in the 3D-map display context. Thus, we posit:

H4a: *In the case of presenting 3D-map on the smartphone, the display of estimated travel time information would result in shorter perceived travel distance than the display of direct-distance information.*

H4b: *In the case of presenting 3D-map on the smartphone, the display of estimated travel time information would result in higher intention to travel than the display of direct-distance information.*

4 RESEARCH METHODOLOGY

We will adopt two laboratory experiments to validate the hypotheses. The first laboratory experiment will examine the main effect. We employ four treatment groups with the sole presentation of travel distance information or visual geospatial information in each of the groups (group 3, 6, 7, 8 in Table 1). We will conduct the second experiment with a 2×2 between-subject factorial design (group 1, 2, 4, 5 in Table 1). The second experiment is aiming to examine the joint effect.

For all of the treatment groups, we will provide the numerical distance indicator (e.g., 80 meters) for the display of direct-distance. We will also provide the numerical time indicator (e.g., 6 minutes) for the display of estimated travel time. For the display of visual geospatial information treatments, we will provide both the 2D- and 3D-map displays with the same plotting scale, same positioning direction, and similar color fillings (Menon & Raghubir 2003). The only difference between the 2D-map and 3D-map displays is the number of dimensions it shows. We will also use two virtual pins to highlight the starting point and the end point on the maps. A mobile application will be developed to manipulate and deploy these treatments. This treatment setting of laboratory experiment is in line with most of prior literature (Raghubir & Krishna 1996).

	Display of direct-distance	Display of estimated travel time	Sole availability of visual geospatial information
Display of 2D-map	Group 1	Group 2	Group 3
Display of 3D-map	Group 4	Group 5	Group 6
Sole availability of travel distance information	Group 7	Group 8	

Table 1. The design of treatment groups

For the measurements of travel distance perception, a slide bar in the mobile application will measure the travel distance perception (IJsselsteijn, et al. 2005). Users could move the bar to a position that best reflects their perception of the travel distance. For the intention to travel measurement, we will use the items from prior literature (Murphy, et al. 2007). All of the items will be revised to fit the research context of the research-in-progress. We will conduct several pre-tests to ensure the validity and reliability of the scales.

In both of the laboratory experiments, we will control for several variables with the aim of reducing the contingency influence. First of all, an important precondition of this study is the absence of the estimated travel distance in users' memory (Montello 2009). In this regard, we will test the subjects' familiarity of the territorial area that will be used in the experiment. Subjects with low familiarity are eligible to join in the study. Second, based on the suggestions from prior literature, we will control the gender ratio among different treatment groups (Nasar, et al. 1985), the attitude towards time and distance (Kang, et al. 2003), and subjects' information searching strategy (satisfying and optimizing) (Guo 2001). Third, for the decision task characteristics, we will control the task interestingness, task complexity, task difficulty, and task emergency by using the pre-tests (Irmak, et al. 2011). Lastly, for the size and resolution of the map, we will provide the same model of mobile devices to all subjects (Kulju & Kaasinen 2002). This method could ensure the same appearance of the map across different treatment groups.

Subjects: 240 subjects will be recruited to participate in this study. We will randomly split the 240 subjects into eight groups. The subjects' age will between 20 to 25 years old. On average, the subjects should have similar mobile device literacy and the mobile map usage experience among the treatment groups (Bohnenberger, et al. 2002). For the experiment incentives, each of the subjects will be given the extra course credits plus an amount of monetary incentives.

Experiment procedure: Both of the laboratory experiments share the same procedure: When subjects come to the laboratory, each of them is randomly assigned to one separated cubicle. We will provide the same model of mobile devices to all the subjects. The subjects then log in the mobile app by using a designated account. Next, the subjects will be asked to fill in their demographic information. After that, they will listen to pre-recorded instructions and view the instruction of the experimental mobile application. In the next step, the subjects will be asked to look at the environmental distance information of a store presented in the mobile application. The experimental scenario is purchasing a gift for one of the closest friends from that store. This scenario is consistent with experiment scenario in consumer behavior studies (Wood & Lynch 2002). After reading the information, the subjects decide whether to go to the store. After making the decision, subjects will move a slide bar to indicate the perceived travel distance and fill out a questionnaire of the intention to travel. When the subjects finish the questionnaire, they will be given the monetary incentive and dismissed. This setup is consistent with most experimental studies on information-seeking and decision-making behaviour (Haubl & Trifts 2000).

5 DISCUSSION

This research-in-progress intends to make three contributions:

First, this research-in-progress empirically operationalizes and validates the human's environmental distance information cognitive processing model (Montello 2009). This conceptual model is derived from theories of cognitive information processing (Ford 2004). Compared with other alternative theoretical foundations for distance judgment, such as accessibility-diagnosticity framework and ease-of-retrieval framework, this conceptual model provides the detailed cognitive processes of retrieving, encoding, and utilizing the environmental distance information (Menon & Raghubir 2003). An issue with this model is that it is higher conceptual and abstract in nature with little clue of how it is to be translated into empirical operationalization. To complement this research gap, this research-in-progress argues for the empirical utilization of the environmental distance information as the travel distance information and visual geospatial information. In addition, this research-in-progress advances the theoretical argument of this model with the consideration of the empirical operationalized environmental distance information. Hence, the present research-in-progress could provide a more holistic understanding on the impact of environmental distance information on the travel distance judgment.

Second, commercial implementations of the travel decision aid are abundant in the mobile communication industry. This is best exemplified by the widely available of 2D- or 3D-map display and other navigation applications on smartphone (Noguera, et al. 2012). However, both scholars and practitioners are lack of understanding on how to effectively present the geospatial and travel distance information in terms of the conditional situations (Kang, et al. 2003). This research-in-progress complements this research gap by arguing that the impact of estimated travel time and direct-distance could be contingent by the provision of visual geospatial information (Oleksiak, et al. 2010). When processing the travel information, users would have the mental integration of the travel distance and visual geospatial information (Montello 2009). If the visual geospatial information could explicitly deliver the destination/route visibility, then the direct-distance information could facilitate the consumers' travel distance judgment. Otherwise, the estimated travel time will outperform direct-distance information in enhancing the travel distance judgment. This argument provides an interesting perspective to understand the consumers' cognitive processing of information for travel. It indicates consumers would not merely use the ease-accessible information to make a judgment (Kang, et al. 2003; Menon & Raghubir 2003). Rather, they would use a set of information processing methods to generate the travel distance judgment.

Third, this research-in-progress provides applicable guideline to practitioners for the best utilization of the travel distance information and visual geospatial information in the business campaign activities. Store managers could develop a mobile application to identify consumers' location, and then provide the appropriate travel distance information with the particular presentation of visual geospatial information. For example, when consumers switch the mobile map into the 3D model, the presentation of travel distance information will automatically change to the estimated travel time.

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