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◆CONTENTS◆

Impact of Nationality Information in Feedback on Trust in a Foreign Online Store

Keywords:
Electronic commerce, consumer behavior, trust, risk, feedback, cross-border

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Abstract

An experimental study was conducted among Japanese consumers in order to investigate the effects of nationality information in feedback on trust towards a foreign online store. Three experimental conditions were created: (1) feedback from Japanese users, (2) feedback from Thai users and (3) a control condition of no feedback. We hypothesized that showing feedback from Japanese users would result in the highest level of trust, and that an increase in trust would then result in lower perceived risk, and higher perceived usefulness and intention of use of the website. A survey was conducted in Japan, obtaining a total of 915 participants who were randomly assigned into three groups corresponding to the experimental conditions. Structural equation modeling was used in order to analyze the proposed hypotheses within a model of consumer behavior. The results indicate that showing feedback from Japanese users resulted in higher trust than showing feedback from Thai users or showing no feedback. However, feedback from Thai users did not result in an improvement of trust when compared with no feedback shown.

1. Introduction

Online shopping is no longer an uncommon activity for consumers. According to the Nielsen Global Trends in Online Shopping report (2010), only 13% of respondents in Asia Pacific indicated that they had never shopped online, and in Japan, 80% of online consumers had plans to make an online purchase in the near future. Although adoption of online shopping continues to improve, for the most part this is the case for domestic online shopping only. Cross-border electronic commerce, which is shopping online in stores located outside the consumer's country, presents additional challenges and has not improved at a comparable rate. One of the main reasons for this is uncertainty in the consumers (Consumer Affairs Agency of Japan, 2011). Consumers perceive higher barriers and risks in cross-border online shopping compared to domestic online shopping (Commission of the European Communities, 2009). Therefore, in order to improve consumer adoption, it is critical to increase the consumer's trust in foreign online stores.

Trust in an online store continues to be an important issue for research in consumer acceptance of electronic commerce (Corritore et al., 2003; Grabner-Kräuter & Kaluscha, 2003; Gefen et al., 2008; Karimov et al., 2011). Trust has a major role in improving online shopping, as higher trust results in higher intention of use (McKnight et al., 2002; Gefen et al., 2003; Pavlou, 2003). As a consequence, studies in this area have investigated the different antecedents of trust and potential ways of improving the perception of trustworthiness of websites. User-generated feedback is one of the mechanisms used in order to build trust (Dellarocas, 2003), which has been implemented widely in online stores. According to the Nielsen Global Trust in Advertising and Brand Messages report (2012), consumers all over the world trust the opinions of other online consumers and the opinions of people they know. Showing feedback on the website allows consumers to have access to these opinions and the information they contain. However, trust and feedback mechanisms have most often been studied in domestic electronic commerce, and the unique characteristics of a cross-border context have seldom been considered.

The aim of our study is to contribute to the study of trust-building mechanisms in a cross-border context. Based on the findings that feedback from users who share some characteristic with the consumer has a positive influence (Williams, 2001), we hypothesize that sharing the same nationality characteristic with the users giving feedback will have a stronger effect on trust. That is, that indicating the nationality of the users giving feedback on the website should act to help the perception of trustworthiness of the website in the case where the nationality is the same as the consumer's, through a group membership effect. We investigate this effect by using an experimental design, manipulating the nationality information in the feedback shown in the website. The conditions considered are feedback from Japanese users, feedback from Thailand users, or no feedback at all as a control condition.

The results confirm that feedback from Japanese users has a stronger effect on trust than feedback from Thai users and no feedback, though showing Thai feedback was not different from showing no feedback. These findings provide evidence of a possible way to improve

trust in foreign online stores and highlight the importance of identifying the unique characteristics of cross-border electronic commerce.

2. Theoretical Framework

While there are different understandings of trust throughout the literature (Wang & Emurian, 2005), the definition used for this study considers trust as the belief that the vendor will act in a favorable way towards the consumer (Gefen, 2000; Pavlou, 2003). This belief is frequently characterized as multidimensional and composed of (1) benevolence, the belief that the vendor will act in the consumer's best interest; (2) integrity, the belief that the vendor will keep its commitments; and (3) competence, the belief that the vendor will be able to perform their task correctly (McKnight et al., 2002; Gefen, 2002). Trust in a website can be positively influenced by feedback (Ba & Pavlou, 2002; Dellarocas, 2003; Kwahk & Ge, 2012). It has long been established that buyers make their evaluations based on the opinions of others (Burnkrant & Cousineau, 1975) and feedback mechanisms can help consumers obtain that information.

The influence of feedback is greater when the users giving feedback share some similarities or can be grouped along some dimension with the consumer (Williams, 2001), because group situations increase social influence (Deutsch & Gerard, 1955). This effect is even present across cultures. Yuki et al. (2005) found that both USA and Japanese respondents indicated higher trust when the users shared the same group membership than when they didn't. In addition to the content of the feedback, information about the characteristics of the user giving the feedback can also have an effect on the consumer's judgment (Forman et al., 2008).

Nationality, especially in a cross-border context, is a salient characteristic that can be used to make a logical association of users. Users of the same country can form a group based on nationality, and this information can similarly differentiate foreign users as being outside of the group. Nationality information in user's feedback would then give the consumer a clear indication of whether they share the same group membership or not. The information of positive feedback by members of the same nationality group would result in a higher perception of trustworthiness of the foreign online store when compared with feedback from foreign users. Additionally, the positive effect of feedback on trust would be present even when the feedback is from members of another group, when compared with a situation where no feedback was shown in the website.

Hypothesis 1a: Feedback from Japanese users results in higher trust than feedback from Thai users and no feedback

Hypothesis 1b: Feedback from Thai users results in higher trust than no feedback

Risk is defined as the uncertainty perceived by the consumer when considering the possible negative consequences of their behavior (Dowling & Staelin, 1994; Featherman & Pavlou, 2003). Because of the characteristics of online shopping, there are different sources of uncertainty and different consequences for the consumer. Risk has a number of facets, corresponding to the consequences of using online services (Featherman & Pavlou, 2003): (1) performance, related to the functional aspect; (2) financial, related to the monetary risk (3) security, related to the risk of private information

loss; (4) time, related to the waste of time; (5) psychological, related to a negative psychological effect on the users well-being; and (6) social risk, related to the loss of standing among a social group. These facets can be more parsimoniously categorized into two groups according to the type of consequence: material risk (performance, financial, security) and psychological risk (time, psychological and social).

Perceived risk becomes a high barrier that must be overcome to some extent, in order for the consumer to use an online store. Trust becomes important in such risky situations (Mayer et al., 1995), and it helps lessen the perception of risk associated with the vendor by considering their positive or trustworthy characteristics (Pavlou, 2003). Perceived risk reduces the consumer's perception of having control over the results of their shopping behavior, and therefore has a direct negative effect on the intention of use of the online store (Jarvenpaa et al., 1999; Pavlou, 2003). Trust also has a direct effect on intention of use (McKnight et al. 2002), as the characteristics of trustworthiness of the vendor induce the consumer to perceive that a transaction would result in a positive outcome.

Hypothesis 2: Higher trust will result in lower perceived risk of the foreign online store

Hypothesis 3: Higher risk will result in lower intention of use of the foreign online store

Hypothesis 4: Higher trust will results in higher intention of use of the foreign online store

Perceived usefulness is originally defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989). The technology acceptance model (TAM) proposed by Davis (1989), indicates that perceived usefulness along with perceived ease of use are the most relevant factors that affect user behavior towards a technology artifact. Because of the existence of a risk component in the case of electronic commerce, extensions of the original TAM model which include the relationship between trust and TAM factors have been investigated (Benbasat & Barki, 2007).

If a vendor cannot be trusted to fulfill their promise to the consumer, that is, if the vendor is not trustworthy, then the online store is not useful to the consumer because they would not be able to obtain the desired product or service (Gefen et al., 2003). Thus, the perceived usefulness of the online store would increase with higher trust in the website. While ease of use is an important consideration for websites (King & He, 2006), its effect on intention of use is relatively lower than the effects of perceived usefulness or trust (Pavlou, 2003; Gefen et al. 2003). Therefore, because of the experimental design of this investigation and in the interest of parsimony, perceived ease of use is not included in the study.

In addition, following the relationship proposed by TAM, the more useful an online store is perceived to be, the more the consumer will use it (Gefen et al. 2003).

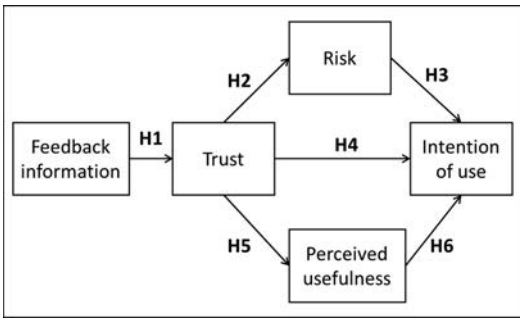

Figure 1 Proposed model and hypotheses

Hypothesis 5: Higher trust will result in higher perceived usefulness

Hypothesis 6: Higher perceived usefulness will result in higher intention of use

The research model is presented in Figure 1.

3. Methodology

3.1. Participants

Japanese online consumers were the target of the survey, which was conducted in Japan. The participants were gathered through a Japanese online survey company, which sent out an invitation for participation to their registered members. First, a preliminary selection survey was conducted among the members who responded, which included questions about online shopping frequency, credit card ownership and demographic information. Participants who had shopped online at least once in 6 months, owned a credit card and were 21 years old or older were selected to take the main questionnaire.

3.2. Experimental design

Three conditions were defined in order to examine the differences caused by nationality information in feedback: (1) Japanese feedback condition (JPF), where the majority of users giving feedback were identified as Japanese; (2) Thai feedback condition (THF), where the majority of users were identified as Thai and (3) No feedback condition (NF), where no feedback information was shown in the website. The NF condition was chosen as the control, as any other feedback information would imply the nationality of the user.

Three versions of a mock up website, a fictitious Thai online store, were developed to correspond to each condition. The content of the mock up websites was written in Japanese. The design and content were identical for all versions, with the exception of the feedback information included for each condition as was described.

The feedback shown in the website was a simple positive non-textual feedback, the equivalent of a "like" to the website in the manner of social network sites (SNS) such as Facebook. In the conditions where the feedback was shown, the information included was a list of the people who had "liked" the website, along with their names and profile pictures. SNS-type feedback was used in the experiment because of the simplicity of presentation, which allowed a basic positive feedback without the need of text or rating-based information. The feedback from the users had no other textual content besides the names.

The nationality information was indicated through the names of the users giving feedback. Japanese names were written in Chinese characters (kanji) and Thai names were written in Thai script and Latin alphabet. The names were reviewed for naturalness by a native Japanese person and a native Thai person.

Thailand was chosen as the foreign country for the experiment because of its relative geographical closeness and for being one of the top tourism destinations for Japanese people, which would help make the scenario more plausible.

3.3. Survey and measures

The selected participants were randomly assigned into one of the three experimental conditions, and asked to view the corresponding mock up website for their condition (NF, THF or JPF) and then answer questions about their

perception of the website.

The questionnaire included items adapted from previous studies: (1) intention of use (Gefen, 2000; Gefen et al., 2003); (2) perceived usefulness (Koufaris, 2002); (3) trust (McKnight et al., 2002); and (4) risk (Featherman & Pavlou, 2003) (see Appendix). All items were measured on a five-point Likert scale from "strongly disagree" to "strongly agree", with the exception of risk items which ranged from "very high" to "very low". The items were translated to Japanese by a native Japanese speaker and their content was then reviewed by a second Japanese speaker.

4. Analysis and Results

4.1. Sample

The survey obtained a total of 915 responses: 311 for the NF condition, 303 for the THF condition and 301 for the JPF condition. The characteristics of the sample are summarized in Table 1. There were no statistically significant differences in the mean or distribution of demographic variables (age and sex) and frequency of online use between the conditions, indicating that the random assignment was successful.

No deviations from normality were found on any variables according to the analysis of the Q-Q plots, and values for skewness indices (SI) and kurtosis indices (KI) were within the acceptable limits of SI<3.0 and KI<10 (Kline, 2011). Multivariate outliers were identified using the Mahalanobis distance measure (D2) and removed, leaving 900 valid cases. There were no missing data. Data validation analyzes were performed using SPSS v18 and Amos v18.

Table 1 Sample summary

		n	%
Sample	Total	915	100
Condition	NF	311	34
	JPF	301	32.9
	THF	303	33.1
Sex	Male	503	55
	Female	412	45
Age	21-29	85	9.3
	30-39	263	28.7
	40-49	297	32.5
	50-59	174	19
	60-69	80	8.7
	70+	16	1.7
Online shopping frequency	1+ times a week	52	5.7
	2-3 times a month	329	36
	Once a month	289	31.6
	Once in 2-3 month	189	20.7
	Once in 6 months	56	6.1

4.2. Measurement model

Confirmatory factor analysis (CFA) was conducted, using Amos v18 with a maximum likelihood estimation, in order to validate the measurement structure of the model. The first-order measurement model was validated first, followed by the second-order measurement model, following Brown's (2006) guidelines for models with second-order latent variables. The criteria used for determining a good model fit was the following: the root mean square error of approximation (RMSEA) should be lower than 0.06 ($p>0.05$), the standardized root mean square residual (SRMR) should be lower than 0.08, and the comparative fit index (CFI) and the Tucker-Lewis index (TLI) should be higher than 0.95 (Brown, 2006). Because of the large sample size, a normed chi-square ($\chi 2/df$) between 3.0 and 5.0 was considered acceptable (Taylor & Todd, 1995; Hooper et al., 2008).

Table 2 Measurement model

		Std. loading	α	CR	AVE
Intention of use	I1	0.86	0.81	0.82	0.69
	I2	0.81			
Perceived usefulness	U2	0.79	0.90	0.87	0.70
	U3	0.80			
	U4	0.90			
Trust	T2	0.80	0.91	0.91	0.71
	T4	0.87			
	T5	0.93			
	T7	0.73			
Material risk (MR)	R1	0.80	0.87	0.89	0.73
	R2	0.89			
	R3	0.87			
Psychological risk (PR)	R4	0.88	0.86	0.86	0.68
	R5	0.87			
	R6	0.71			
Risk	MR	0.92	0.90	0.88	0.78
	PR	0.843			

α Cronbach's alpha

The results showed high correlation (higher than 0.90) between the trust dimensions. In initial trust scenarios, such as the one in this study, users lack enough experience to differentiate between the trust dimensions (McKnight & Chervany, 2001) so instead we modeled trust as a single construct (Gefen et al., 2003). All items had a standardized loading higher than 0.7 but the model did not return a good fit. After inspecting the modification indices and identifying the sources of strain, the model was re-specified by removing items and adding residual covariances. The re-specified model showed a good fit ($\chi2(76)=248.73$ (p=0.0), $\chi2$/df=3.27, RMSEA=0.05 (p=0.46), SRMR=0.027, CFI=0.98, TLI=0.98). A CFA was then conducted on the model with the second-order latent variable of risk, composed of the material risk and psychological risk factors. The second-order model also showed good fit ($\chi2(78)=276.2$ (p=0.0), $\chi2$/df=3.54, RMSEA=0.05 (p=0.21), SRMR=0.03, CFI=0.97, TLI=0.98). Standardized factor loadings for the first and second-order latent variables are shown in Table 2.

Reliability and validity analyzes were conducted. To confirm construct reliability, the Cronbach's alpha and composite reliability values for the factor should be higher than 0.7, and to confirm convergent validity, the average variance extracted (AVE) of the factor should be higher than 0.5. As can be seen in Table 2, all factors showed good construct reliability and convergent validity. Discriminant validity was verified by comparing the square root of the AVE of a factor to the absolute value of the correlations with all other factors (Gefen et al., 2000). For all factors, the square root of the AVE was higher than the correlations, indicating appropriate discriminant validity.

4.3. Structural Model

Structural Equation Modeling analysis was conducted to test the proposed model, using Amos v18 with a maximum likelihood function. Two dummy variables were used in order to represent the three experimental conditions in the structural model (MacCallum & Austin, 2000). The variables were named after the conditions they represented: JPF and NF. The Thai feedback condition (THF) was used as the reference, and therefore not included.

The structural model specified according to the hypothesized model showed a good fit ($\chi2(107)=296.78$ (p=0.0), $\chi2$/df=2.77, RMSEA=0.04 (p=0.93), SRMR=0.03, CFI=0.98, TLI=0.98). The standardized path coefficients are represented in Figure 2. The results show that all

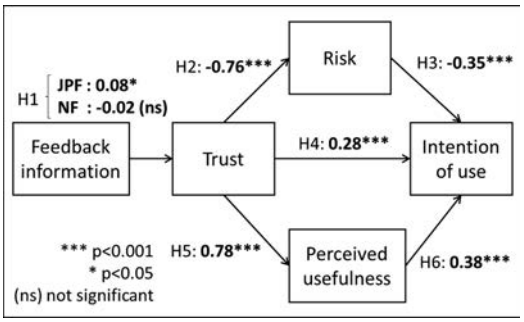

Figure 2 Standardized path coefficients

Table 3 Results

Hypothesis	Path coeff.	Std. error	p
H1a: Trust is higher for JP feedback than for TH feedback	0.11	0.06	0.038
H1b: Trust is higher for TH feedback than for no feedback	-0.03	0.05	0.549
H2: Trust -> Risk	-0.81	0.04	< 0.001
H3: Risk -> Intention of use	-0.43	0.06	< 0.001
H4: Trust -> Intention of use	0.36	0.08	< 0.001
H5: Trust -> Perceived usefulness	0.98	0.04	< 0.001
H6: Perceived usefulness -> Intention of use	0.39	0.05	< 0.001

hypotheses of the model were confirmed with the exception of H1b (Table 3).

5. Discussion

The most important result of this investigation, corresponding to our main hypothesis, was that feedback from Japanese users resulted in higher trust towards the foreign online stores than showing Thai feedback or showing no feedback in the website. This result corroborates the findings that similarity with the users giving feedback can have a positive effect on the consumer (Williams, 2001; Forman et al., 2008); in this study, the similarity was indicated with the characteristic of nationality. Surprisingly, the standardized path coefficient corresponding to the effect on trust for the Japanese feedback was rather low. This may be due to the fact that only very simple positive information was provided by the feedback, as it didn't include a rating system or a review.

The results also confirmed the relationship between trust and the other factors in the model. Trust had a lowering effect on perceived risk, and improved the perception of usefulness and the intention of use of the website. The standardized path coefficients show that, for this cross-border context, the absolute effect of trust on risk and perceived usefulness was more or less equal, with a lower direct effect on intention of use partially mediated by the other two variables. The standardized path coefficients for the effect of risk and perceived usefulness on intention of use were similar, and they were stronger than the direct trust effect. These results are in line with previous studies on the direct effect of trust (McKnight et al. 2002; Gefen et al., 2003; Pavlou, 2003) and add to the work of Jarvenpaa et al. (1999) to validate trust effects in a cross-border context.

There was only one hypothesis which was not confirmed by this study: feedback from Thai users did not have a stronger effect on trust than showing no feedback in the website. That is, there were no differences found in the effect on trust between these two experimental conditions. This is a surprising result that contradicts previous studies, which indicate that positive

feedback improves trust in the website (Ba & Pavlou, 2002; Dellarocas, 2003; Kwahk & Ge, 2012).

One possible explanation for this result is that the cross-border context and the use of a foreign online store in the experiment resulted in greater uncertainty about the trustworthiness of the vendor, and so the presence of feedback alone was not enough to increase trust. Another possibility is that whatever positive effect feedback has on trust is being negated by dissimilarity effects. The implications of these results are that websites should consider carefully how to show nationality information in the case of a different nationality from the consumer.

There are some limitations to this study. First, by using an online survey company the survey obtained responses from a pre-existing group of users, which limits the generalization of the results on the population.

Second, we used a mock-up website for the experiment instead of a fully functional, real online store. This limits the realism of the study, as the respondents were not able to get a complete impression of the website. However, this design was selected to allow for a flexible manipulation of the experimental conditions, along with the content of website, and avoid any external reputation effects.

Third, in this study the nationality was indicated by the user name. While it is possible for a Japanese native to identify Japanese or Thai names, in other cases nationality information may not be as easily identified from names, or they may not necessarily indicate the actual nationality of the user. Still, the consumer uses the information as they perceive it, so even an incorrect perception of country can have an effect on consumer evaluation (Magnusson et al., 2011).

Fourth, the scope of this model was limited and did not consider other factors, such as perceived ease of use, or the effect of refund policies or sales tax, for example. This was done in the interests of parsimony and to retain the focus on the experimental manipulation, but the possible impact is that there may be some bias in the estimated effects. Future research should validate the results with additional factors.

6. Conclusion

This study examined the effect of nationality information in feedback on trust and subsequently on risk, perceived usefulness and intention of use, in a model of consumer behavior in a cross-border electronic commerce context. We investigated the difference in impact between three different conditions: Japanese feedback, Thai feedback and a control condition of no feedback.

The results showed that feedback from users of the same nationality as the consumer results in higher trust than feedback from foreign users. And that feedback from foreign users did not improve trust in a foreign online store even when compared to showing no feedback at all in the website. The results of this study indicate that nationality information in feedback can help increase consumers' trust in the website, through the perception of a similar group membership.

These findings have some implications for the design of foreign online stores. For example, vendors could identify the nationality of the consumer and use that information to show feedback from consumers of that same country, prioritizing it over feedback from users of other

countries and clearly indicating the nationality. It may be useful for international online stores to consider showing feedback differentiated by country when that information is available.

Future studies should consider nationality effects in combination with more complex feedback content, such as positive or negative reviews. The model could also be validated using other countries, to compare the results obtained. In addition, a third nationality could be added to the analysis, in order to test country-of-origin effects by comparing the impact of feedback from two different foreign user groups. In a more general sense, future studies in a cross-border context should endeavor to identify other factors that uniquely affect consumers in cross-border electronic commerce, such as the perception of the foreign country, logistical challenges or security concerns.

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8. Appendix (Measurement items)

Intention of Use (Gefen, 2000; Gefen et al., 2003)

I1 Given the chance, I would provide this online store with the information necessary to make a purchase.

I2 Given the chance, I would use my credit card to shop from this online store.

Perceived usefulness (Koufaris, 2002)

U1 Using this online store would improve my performance in my shopping.

U2 Using this online store in my shopping would increase my productivity.

U3 Using this online store would enhance my effectiveness in my shopping.

U4 I would find this online store to be useful in my shopping.

Trust (McKnight et al., 2002)

T1 I believe that this online store would act in my best interest.

T2 If I required help, this online store would do its best to help me.

T3 I believe that this online store would act in my best interest.

T4 This online store is truthful in its dealings with me.

T5 I can trust this online store site to process and deliver my shopping correctly.

T6 This online store would keep its commitments.

T7 This online store is sincere and genuine.

T8 This online store is competent and effective in selling products online.

T9 This online store performs its role of selling products online very well.

T10 Overall, this online store is a capable and proficient online store.

T11 In general, this online store is very knowledgeable about shopping online.

Risk (Featherman & Pavlou, 2003)

R1 The possibility that the products delivered by this online store may fail to meet my expectations is:

R2 The possibility that I stand to lose money if I use this online store is:

R3 The possibility that using this online store will cause me to lose control over the privacy of my payment information:

R4 The possibility of losing or wasting time by using this online store is:

R5 The possibility that using this online store will cause me frustration is:

R6 The possibility that using this online store will cause people I know to think less highly of me is:

Exploratory Research on Social Media and Digital Writing : Qualitative Interview of Japanese College Students

Keywords:
Social Media, friendship, interpersonal relationship, connected presence, cultural factor

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Abstract

This exploratory study examined how indigenous social media relates to college students' peer interaction and cultural involvement toward digital writing on social networking services (SNSs) in Japan. A qualitative research design was adopted that involved semi-structured in-depth interviews with eight university students on social media participation to investigate the role new technologies play in the establishment of peer connection practices. It was found that the respondents employed SNSs to connect with friends and to establish a sense of belonging by using a "connected presence" strategy. A thin but perpetual sense of membership belonging was developed mainly through silent online participation behavior which enhanced transient friendships. In addition, connected presence strategies that contribute to humorous content and emoticons were analyzed and it was found that social media facilitated the creation of easy-going online identities, which defuses tension, discomfort, or conflict. Finally, it was found that cultural traits such as a "psychological status of shame" and an "extreme sense of privacy protection" could have an impact on the digital writing of young people.

1. Introduction and Research Questions

As increasingly more people make use of the Internet, social media is becoming an indispensable part of everyday life. Social media refers to the Internet-based applications that allow people to create and exchange content using digital network technologies (Boyd & Ellison 2008). In the US, Facebook is the dominant social media, with 93% of teen social media users having an account, according to a 2012 report (Lenhart 2012). There were approximately 168 million Facebook users in the United States and 1 billion users worldwide as of October 2012 (Na et al. 2014).

Further, MIC[1] reported that 57.1% of the Japanese used social media and the three main social media platforms were LINE[2], Twitter, and Facebook. More than 70% of adolescents in Japan are engaged in one of these social media, with LINE, an indigenous social media, becoming a central part of social interaction for Japanese digital natives, with more than 80% of teenager participating. The digital natives are the generation born after the general introduction of digital technologies who have grown up immersed in and familiar with these technologies (Seo et al. 2013). More than 50% of the Japanese younger generation use Twitter, which is ranked as the second most popular social media in Japan. Almost 40% of Japanese use Facebook, but this is not as popular in the younger generation in Japan (ICT lab 2014[3]).

Even though the most popular SNSs are different in each country, social media plays a crucial role in the lives of the networked younger generation in Japan. Digital media, such as mobile phones or social media, is a connectivity technology that allows users to connect with their families and friends *at all times* (Campbell 2006). While the specific technologies differ, collectively they provide users with a space to hang out with friends. When examining the associations between social media and interpersonal networks, social media has been found to generally support both the maintenance of existing social ties and the formation of new connections. Much of the early research on online communities assumed that the individuals using these systems would be connecting with others outside their pre-existing social groups, as opposed to those within their shared geography (Wellman et al. 1996). Although this early work acknowledged the ways in which offline and online networks blend into one another, the assumed online to offline directionality may not apply to today's SNSs, which are structured to both articulate existing connections and enable the creation of new connections. Hampton and Wellman suggested that information technology such as social media may enhance place-based communities and facilitate the generation of social capital (Hampton 2002; Hampton and Wellman 2003). In this regard, it can be assumed that by utilizing social media, college students facilitate their relationships with friends they frequently meet on campus.

Social Media and "Connected Presence" for Online Friendship

The primary goal of the present research is to examine how newly diffused communication tools, such as social media, are used by college students who have just started their life in a university. In particular, how they initiate and manage new relationships with their friends using social media in everyday life is examined.

What kind of communication takes place on

social media and how are friendships made at the campus?

From the results of previous research, most young people began their days by checking messages on SNSs and spent the entire day on them or a connected/online world (Yang 2014). This form of existence is known as "connected presence", a concept presented by Licoppe (2004) in his research on mobile communications. Licoppe asserted that compared with landline phones, mobile communication tools, such as SMS mediated interpersonal interactions, and were configured to maintain links over distance through a "continuous" presence.

This research also investigates the significant development of "frequent, short digital writing" (Licoppe 2004) on platforms such as Twitter or LINE. These short writings allow or enable people to maintain connections with friends and are more marked among young users.

Ling (2004) demonstrated that mobile phone innovations have dramatically changed friendships and practices for young people. Young people are able to contact their friends more rapidly, economically and simply; further, they can use messaging to share information enabling them to develop and maintain strong peer networks.

However, Bauman (2003) argued that connectivity technology has fragmented friendships, leading to superficial connections. Further, Yang (2014), on the basis of an examination of Taiwanese young peoples' use of Facebook, asserted that connectivity technology has become a type of filter for screening or categorizing friends and not for deepening or integrating friendships Bauman also asserted that categorizing friends into various types has become a method for managing risks in intimate relationships and for controlling intimacy (Yang 2014).

The hypothesis for the attenuation of relationships in the younger generation discussed above because of new connectivity technology, such as mobile phones, has also been discussed in Japan with the emergence of mobile phone in the late 90s. Previous research has shown that the friendships for Japan's younger generation have become wider but thinner (Ohira 1995; Matsu 1990). However, several researchers such as Hashimoto (1998), Matsuda (2000), Tsuji (1999), and Asano (1999) strongly negate this finding as no empirical studies have been conducted that support this claim. These interpretations may have been distorted by cohort effects, sampling bias, and mass media effect (Hashimoto 1998; Matsuda 2000). Matsuda (2000) also demonstrated that urbanization increases the number of possible contacts, and hence, it promotes selective relationship formation. Moreover, she asserted that mobile technology is not a factor in the attenuation of human relationships in the youth.

On the basis of these prior studies, the following question is proposed herein:

RQ1: How is digital writing by the younger generation employed to maintain their friendships through social media and how social media can affect their relationships?

Association of Cultural factors and written communication on Social Media

When discussing the attenuation of friendship hypothesis, it is necessary to consider the various meanings of friendship across cultures (Adams & Plaut 2003). Castells (2009) gave a magnificent insight on the relationship between technologies and culture from a global perspective: "there is a

youth culture that finds in mobile communication an adequate form of expression and reinforcement. All technologies diffuse only to the extent that they resonate with pre-existing social structures and cultural values"

Namely, if youth culture is to be discussed, it is necessary to consider the culture and social practices embedded in young people's everyday life.

Previous research conducted in an Asian context suggests that cultural differences might be a factor in the significant behavioral differences in computer- mediated communication tool use between South Korea and Japan. For example, the differences between Japanese and South Korean communication behavior with respect to BBS, as demonstrated in previously reported surveys demonstrated these differences. More than 70% of Korean university students surveyed in 2008 accessed BBS at least once a day[4]. Further, 25.1% of those who regularly accessed bulletin boards (BBS) wrote on these boards, while only 3.1% claimed that they "never write on bulletin board." (Kim 2003). However, in comparison, the Japanese use of communication tools, such as BBS and community sites, appears to be more restrained. Research has indicated that all but a very small minority of users on these sites initiate a two-way communication and were "read only" users (Kim 2003). Analysis of the use habits of the registered members of a psychological forum revealed that 83% had never written anything on the site even one year after it was established. Of those who had written, two thirds had done so three times or less[5]. Therefore, the frequency of posting on BBS and the motivation for engaging with the site are different. According to a previous study, the Japanese use BBS for "information exchange," while the other categories of motivation, such as to debate issues, to form interpersonal relations, and to attract other people's attention to their own existence (self-presentation), are insignificant in comparison. In South Korea, in contrast, BBS are frequently used as a medium for debate and the exchange of opinions on numerous matters of public interest, including political and economic issues of the day (Kim 2003). Accordingly, the use of a tool is closely associated with the cultural and social perception (Gibson 1979) of that tool, thus cultural and social backgrounds have a distinct effect on the engagement with and the participation in the communication tools. Each culture, therefore, is likely to have its own distinctive associated behaviors, usage patterns, and effects. Moreover, when investigating these cultural differences, *communication styles* and the manner in which interpersonal relations are conducted must also be considered as potential causal factors.

For example, communication within the in-group *(uchi)* is conducted differently from communication with those outside *(soto)* (Nakane 1967). In addition, there is a tendency to avoid publicizing personal information in Japan (Kim 2010). This reflects the mentality of "not wanting to be seen", and together with the emphasis on privacy protection in the mass media, has led to the creation of a distinctive Japanese Internet culture. In this study, the possible effects of such cultural factors on the contribution behavior toward such social media are investigated. On the basis of previous studies, the following question is proposed:

RQ2: How do the cultural and social differences in communication styles affect the ways in which people participate in digital writing on social

media?

While it is recognized that different social media interfaces have various communicative functions, this paper mainly focuses on how the interpersonal functions are used to form and maintain ties, rather than on categorizing the functions according to the media traits. In addition, the social and cultural characteristics of digital writing by the Japanese youth are analyzed in terms of their participative behavior on the Internet. This study also attempts to identify some of the socio–psychological factors at play in social media.

2. Method

Qualitative approach is usually adapted not only to clarify the dyadic or triadic causal effect among factors but also to acquire the tentative appreciation and/or speculation by considering participants' social and cultural proposition.

In this study, for preliminary investigation for the effect that social media has on college students' connectivity and friendships, and to examine their daily interactions by considering their social practices and the culture, a semi-conducted and in-depth interview method was adopted. A purposive sampling method was used and significant sampling variations such as gender, economic background, and life style were considered. First year students from a university located in a specific city who claimed to have experiences with friendship were recruited.

A total of 8 respondents were examined, four females and four males. In addition, all students belonged to certain clubs or circles[6]. Almost all participants used LINE and Twitter but and only three had a Facebook page. Each student was interviewed several times. With their consent, each interview session was recorded. The content of the interviews was then transcribed and combined with field notes for data analysis. A thematic analysis was conducted in this study by thoroughly and repeatedly examining data to identify frequently mentioned topics that were closely related to the interviewee's life and the social and cultural effects on their digital writing. The experiential data was then analyzed to obtain answers to the research questions.

Table1. The detail of Participants

	Sex	No.of member to reside	Age	SNS	Interview Date
A	m	1(single)	19	T/L/FB	Dec.5.2014
B	m	2(with mother)	18	T/L/FB	Dec.8.2014
C	m	4(With family)	20	T/L	Dec.8.2014
D	m	3(With family)	20	T/L	Dec.15.2014
E	f	5(With family)	19	T/L/FB	Dec.15.2014
F	f	1(single)	19	T/L	Dec.15.2014
G	f	4(With family)	19	T/L/FB	Dec.15.2014
H	f	5(With family)	19	T/L	Dec.15.2014

*T:Twitter, L:LINE, FB:Facebook

3. Findings and Discussion

The participants in this study were so called digital natives who had experienced the evolution of digital technology. They had graduated from high school around eight months ago and were making great efforts to adapt themselves to a new environment and to make new friends.

The three major activities for the Japanese university students were identified: attending classes, participating in club activities, and/or working at part-time jobs. While busy doing these three activities almost every day, they were also devoting themselves to socializing using their smartphones. It is already well known that more than half of social media users access SNSs

using a Smartphone (MIC 2014).

They needed to initialize interpersonal relationships for not only useful reasons but also for psychological stability. The socializing was continuous but also appeared to be extremely difficult to deal with. Although they had different perspectives on the media usage and friendship, the central focus of their life was their study, club activities, and/or part-time jobs. When examining these experiences and the relationship interactions during their lives on the campus, these experiences and interactions must be considered within their life context and social landscape to better understand their emotional experiences and relationship practices (Yang 2014).

Effect of Social Media on the student's connection with friends and on establishing a sense of belonging

Participants did not make phone calls but spent most of their time online on their smart phones except when studying or involved in club activities. All participants expressed a desire to exercise their will power to control the use of their smartphone or the time spent engaging in social media.

All respondents used LINE and were involved in two types of combinations: individual chatting and group chatting. When asked how many LINE groups they were engaged in, participant A had joined 34 groups on LINE but was actively involved in only 5 of these. The other participants had also joined tens of groups on LINE. However, further questioning revealed that few interacted regularly with more than five. Further, their individual chats on LINE also did not exceed with five people.

LINE group chatting potentially satisfied the students' need of belonging but the number of members participating in each group varied. For example, most students generally belonged to groups from the same department or those associated with their club activities. In addition, other small groups were often offshoots from the mother group to fulfill the participants' individual purpose.

Group chatting involved scheduling and the announcement of various kinds of events and activities. There were usually core member who gave announcements in the chat group on LINE, and there was no useless chatter.

Thin but perpetual sense of belonging to membership with silent participation

Most participants seemed quite satisfied with being a group member on LINE to find about the latest class activities without needing to talk. For example, even student D who was an outgoing person did not initiate any dialogue on LINE group chatting. Participants felt connected to the other people through the continual flow of small communicative acts. As is well known to LINE users, LINE offers a read/unread function to mark the state of a message. If marked as "Read *(Kidoku)*" this indicates a "silent participation". As participant, D stressed below:

D: I don't and can't speak in group chat to all classmates. And I don't know who created the group. But, the "read (*Kidoku*)" number soon becomes 20, 30, 40, so it seems surely to be reliable.

Female participants, such as F and G, in particular, used group chat on LINE extensively. Even though they did not voluntarily post announcements and just "lurked (silent

participation)," they enjoyed the sense of belonging to a specific group.

F: Captain or the person in charge of the drinking party, or a manager, informs everyone of something there annually. But we only read it and then it's over.

G: There is a group on LINE of all the students in the same department. It is used for business contacts. We don't have any class monitor so everyone feels free to speak there when he or she notices something, such as who passed the exam, and if "Everyone passed the exam", sometimes they send photos. Everyone is reading it. But I don't write there.

"Silent participation" or interposing more visibly between people is another form of "connected presence," because participants fear they would be isolated from others and unable to "catch up" with events in the outside world. The social implication of the "connected presence" of social media can be defined not as communication but as small expressive gestures between members.

This "silent participation" tendency was also found on Twitter. Most participants did not focus on or were not enthusiastic about commenting on Twitter and they typically only read other people's latest status posts and checked what others were doing. Nor did respondents follow celebrity twitter feeds and rarely posted social or political issues.

G: I read Twitter everyday but basically don't post on it. I read the timeline, see others' feelings and read what they are doing. I don't follow celebrities; I just want to know how my friends are doing. We share and respond, and say "happy birthday" to each other.

No participant checked or tweeted regarding social issues or news. Consequently, they were reluctant to post, reply, or retweet serious or political opinions on Twitter. They were more likely to evade heavy or negative topics like social issues or depressing feelings and troubles on social media. When they encountered excessive demands from others, social media enabled the participants to conceal their true feelings and maintain their calm. The characteristics of the "connected presence" also allowed them to express only pleasant or positive information, as highlighted by B:

B: An intense environment is the most troublesome. For example, I am always careful to avoid embarrassing situations like saying something that makes others speechless. I don't talk seriously on Twitter. I use it to write something light and insignificant, such as "I just watched a speech of Suga-san on TV, and what a weak-willed person he is." That's all.

Sharing amusing content to enhance emotional connection

Young participants show their feelings by sharing humorous content and making other people laugh. By making friends happy and finding common points to laugh about, they feel relaxed and fulfilled with their friendships when using social media.

E: If someone likes my post, I would be very happy. It means that someone is definitely looking at my post! I feel very happy. I don't know the way to make people like my posts. There are people who are good at it. They can tell something funny

and get laughs.

Participants shared humorous content because it made them seem to be an open minded person worth connecting to. Further, they wanted the audience to appreciate their sense of humor. Most respondents shared humorous movies or pictures on social media. Female participant, F, stated the following:

F: Basically, I login to an account that has my actual friends. I use the accounts when I am free. I absolutely post once every day about something that happened on that day, or about some funny guy on the train. I want to tell interesting stories to everybody. If I get a response like "it's interesting!" I am very happy because it means it is interesting not only to me but also to others. I feel satisfied with providing funny stuff that can make others laugh.

Participants were known to avoid in-depth discussion and preferred to maintain thin interpersonal relationships with friends on campus. From previous studies on the younger generation's interpersonal bonds, Matsui (1990) found that compared to the past, young people did not want to maintain deep friendships but wished to associate in a segmented way (Matsui 1990). For example, F commented that she did not want to reveal her hobbies even to intimate college friends without a specific reason and did not seem have any feelings of guilt about hiding this information or not revealing all her feelings, as she said.

F: Actually, I don't talk about the bands I favor with my friends. I never want to expose myself with intimate people from the same department. I don't want to show my interests to them. When I went to a concert, and they asked where I went and I say, "it's secret"…and because I am busy with a part-time job and club activities, I don't have much time to check LINE. I read it after my job and club, but mostly the talk has already finished. It is a little disappointing to see them talking happily (without me). A little while ago, the other 4 people went out while I was attending a course (because I take a different course), and they seemed to be having a great time. Then they uploaded a picture to group. I thought "why did they upload it here?" but still, I wrote "You looked happy". I felt lonely about this.

Online relationships provide and satisfy friendship needs without requiring the effort of real world friendships. In the past, the characteristics of a good friend included trust, honesty, and loyalty (McLeod 2002). Students experience uncertainty regarding the maintenance and selection of friendships because of the many interactive characteristics of digital networks and their busy lifestyles. As Yang mentioned, connectivity technology has caused student friendships and interpersonal relations to become random and flexible. Loyalty exists in a stable and continuous in-depth association between people. In addition, because these thin-level interactions are "frictionless," they provide a happy, satisfactory type of relationship (Yang 2014).

The individual LINE messenger was found to be used as a supplement to face-to-face interactions between people who were already acquainted. Friendship in the past has been defined as to "perceive and sympathize with another's feeling (*Sassuru)*", but research has shown that this has changed to do not go in-depth

of each other's feeling (*Tachiiranai*)" (Ohira 1995). This assumption is based on the "hypothesis of attenuation of interpersonal relations in the youth" in Japan. Evidence for this claim was provided by the student interviews, as can be seen in the statements below.

A: If I see something negative or something not very good on Twitter, I just leave it alone and don't touch it. For example, if I saw my friend post "I had a hard time...", I would think that maybe something had happened to him or her. But I would not reply to it.

C: I don't unburden my problems on LINE. If I want to talk about them, I'd like to talk face to face. I don't like being misconstrued.

Current digital natives were found to "avoid intruding into other peoples lives." In addition, they adopted "emoticons" as a resource to ease friction on social media. In other words, emoticons were not only used to express their genuine feelings or emotions but also functioned as "emotional lubricants" to manipulate and control their authentic "negative" emotions so as not to hurt or offend others' feelings.

A: My friend once sent me a picture and said it was interesting. I really didn't think so, but I had to say something about it. So I just sent him an emoticon displaying "very interesting!" to "deceive" him…Rather than cheating, it is somewhat troublesome. If I say "it isn't fascinating", the exchange of dialogue will continue which is very troublesome. So instead of saying, I finish and run away from the chat by using an emoticon.

C: It's not so good to speak to new friends at college with a cold attitude, so I usually use Emoji[7]. I can speak to people with a long friendship curtly but intimately. But I can't talk curtly to friends who I haven't spoken to since over half a year.

F: If we get along well with each other, it's okay to talk casually. I use Emoji when I talk to someone I am not familiar with.

Interestingly, emoticons are more frequently used for superficial friends/acquaintances. A possible explanation might that campus friends do not know each other for a very long time as they had only recently met, and they have to get along with each other for four years; therefore, they tend to use emoticons to lighten the atmosphere.

In addition, from the interviews, it became apparent that gender came into play when using emoticons. G explained that he used Emoji according to the recipient's gender.

G: I feel that, I don't need to pay attention when I talk with a man on LINE. I don't need to use Emoji; it's okay to use just words with guys... However, I have to pay attention when I talk with a girl.

Digital Writing Reluctance and Shame (Haji) Culture

C, a somewhat reserved person, started using Twitter when he entered a university but quit 3 months after. He explained his reason below.

C: I feel ashamed. It is alright to post something about events related to other people, but when it comes to my history or what was happening to

me, I had no idea how I should deal with it on Twitter. And...I have had interactions with someone on Twitter, but this ended because of my curt responses. I don't like leaving my footprints–interactions on others on Twitter as my correspondence is revealed. I hate it. It's better to use LINE. I don't understand why it has to be done on Twitter.

C gave three reasons why he quit Twitter. Firstly, he felt pressure to write about himself while being conscious of the attention of others. Secondly, he was anxious and embarrassed to have dialogues without any visual social cues such as nonverbal expressions. He mentioned that he sometimes even deliberately cut off the interactive communication. Lastly, he felt psychological pressure about releasing his private information to others and a fear from the ability of others to read the visiting history.

Consequently, the other-oriented communication style and the accompanying obsession with how they are viewed by others could be seen to be related to the structure of "shame", a subject on Japanese culture which has had many commentators (Benedict 1967). The other-oriented communication style is the most typical of the communication that was found to occur within the circle of the primary group to which an individual belongs. The desire not to "stand out" and to blend in with the group is a feature of this style of communication.

Moreover, people in individualistic cultures prefer to "stand out," whereas people in collectivistic cultures prefer the self to "be effaced and dissolved into" their in-groups (Triandis 1995). Therefore it can be assumed that people in individualistic versus collectivistic cultures would have different types of digital writing styles.

In addition, owing to Protection of Privacy, it usually prevented the students from building new social bonds on the Internet. Almost all respondents locked their twitter accounts so people they did not know face-to-face were unable to access the account.

Twitter allows any anonymous person to create a weak connection, which allows them to gain access to a broad range of heterogeneous information. However, this was not the case for most of the participants in this study. Further, more females tended to fold or close their twitter accounts than males. H asserted below.

H: I think in order to protect our privacy and enjoy the social media, locking the account is a very effective way. If your twitter includes individual information, lock the accounts! You can allow only people you give permission to to read it, and this is what you must do! And I don't want to get to know or need to know new people through twitter. That is scary.

Personal home pages did not feature individual or family members' photographs to the extent they do in South Korea or the United States (Kim 2004). This could be to avoid accusations of arrogance or attention seeking as well as to maintain personal privacy. Twitter allows users the chance to create and gather new and heterogeneous information from other countries, but it was found that these Japanese college students ignored this function and used only a limited part of Twitter. The female students, in particular, were more concerned about privacy protection.

G: Because I've locked my account so others cannot see my Twitter. And I open my name and

the name of the city where I live in to the public on Twitter. Sometimes, someone just wanted to follow me by seeing my name. But…I don't like showing my photo to people I don' now.

Japanese people tend not to express opinions on political or economic matters (Kim 2010). In computer-mediated communication (CMC) research, issues that could potentially become topics of debate tend not to be taken up. The very act of raising such topics could attract the accusation of being *medachtagariya* ("attention seeking"). On my speculation, even in academic contexts where lively debate might be expected, there tends to be an avoidance of direct expressions of opinion, especially where there is a possibility of disagreement, in the interests of maintaining at least the outward appearance of consensus. Despite participant A tended to write something related to politics, he was too anxious about how peoples would assess and consider his contribution of that kind of topic. A explained below.

A: For example, when I write my opinion about the news, I write some, but then I just stop and delete it. There are other opinions about the news, so I feel like it's better for me not to put my feelings into it. So I rarely say anything serious on Twitter. There are so many different opinions. If I write too much about mine, I think my friends would be sick of it and I hate it.

Conclusion

This study took an exploratory approach to examine college students' perception of friendship, how they used social media, and the cultural factors associated with their reported behavior to form and maintain their human relationships. Studying young people's friendship in the context of social media is important, as these platforms are significant for practicing and experimenting with friendship.

A key finding was that social media was found to play an important role in the students' connection with their friends and in the establishment of a sense of belonging through deploying a "connected presence" strategy. Most of all, a *thin but perpetual sense of belonging to a membership* was found through a silent online participative behavior, which was found to enhance transient friendships. Marking other posts as "Read" on LINE was a small communication gesture to show their existence and to maintain friendships. These results are consistent with previous studies that investigated Japanese lurking behavior on BBS (Kim 2004). However, the psychological reasoning for these two kinds of online behavior might be different. While these two behaviors have common factors such as the demand for reciprocity, these were found to be relatively weak compared to individual chat on other applications. However, communication on BBS is often with unknown and anonymous people, whereas group chat on LINE is most often with known acquaintances. As this research did not investigate whether/how the respondents participated on BBS and did not compare the psychological behavior, the results should be interpreted with caution. However, as silent communication on SNSs in the younger generation has been observed in other countries such as Taiwan (Yang 2014), it cannot be assessed to be a unique trait for the Japanese.

In addition, the analysis of the strategy of posting amusing content and using emoticons to demonstrate a "connected presence" indicated that social media facilitated the creation of easy-

going online identities so as to defuse tension, discomfort, or conflict.

Secondly, contrary to the results from CMC research in North America and Europe, the Internet-use patterns differed according to local cultural and social circumstances. When considering how such communication affects the formation of interpersonal relations and the exchange of emotions and opinions, it is necessary to take such cultural factors into account. This paper has suggested some of the ways in which these effects may occur. For example, the cultural traits of "psychological status of shame (*Haji*)" and "extreme sense of privacy protection" could affect the extent of digital writing and contribution by young people. An interesting finding was that most respondents locked their Twitter accounts so strangers could not make contact. Therefore, Twitter was not used to express open opinions, as is the case in other countries, but was only used to share status with known acquaintances. These results were opposite to the tendencies found in previous findings that explored the association between teens' social media and collective action. For example, in the USA, it was found that teen online behavior gradually unmoored them from their local geographical setting. (Seo et al. 2013).

There are some limitations of this study. Firstly, a quantitative approach with a larger and more representative sample would have contributed results that are more generalizable. While the qualitative approach used in this study is an acceptable preliminary method to explore the research questions and objectives, more data is necessary to confirm the findings. Secondly, as the current study was conducted only on Japanese students, it was inadequate for an investigation into the cultural influences on social media behavior. I will aim to examine how the cultural effects on young Japanese living in different cultures might lead to the use of different tools of communication at upcoming study. Lastly, because of the limited study objects, there was not enough evidence to confirm whether social media enhanced "the hypothesis of attenuation of human relationship". Future research should include both quantitative and cultural comparative perspectives.

This paper has attempted to examine how indigenous social media affects the interaction of college students in Japan by examining how "connected presence', and silent participation can enhance transient types of friendships. Gender differences were observed in the reasons for using social media. For example, young men primarily used social media to arrange activities with their friends, whereas young women used it to create and maintain a space for flourishing friendships. The females also reported that their "addiction to social media" was connected to a *connection- dependence* (*Tsunagari Izon*), which was not seen in males. In future research, reflections on the differences between the genders in traditional friendships and how the younger generation constructs their identity in their daily lives using technology needs to be explored and could shed light on academic achievements for both media and gender studies.

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1 Ministry of Internal Affairs and Communications

2 LINE is a mobile messenger service application with free voice and video call. http://line.me/en/

3 http://www.ictr.co.jp/report/20140821000067.html

4 This survey was carried out by Hashimoto-Lab at the Institute of Socio-information and Communication Studies, The University of Tokyo. The survey subjects were university students attending private universities in Tokyo (464 samples) and Seoul (482 samples).

5 The precise breakdown was as follows: once 43%; twice 14%; three times 7%.

6 They were asked in the order of 3 steps below.

1) General inquiries of the personal media, such as frequency, duration, places and history of participation of social media and mobile phone usage etc.

2) How to make and maintain the relationships with their close friends or classmates.

3) The good and bad things of social media and especially perceived effects in terms of relationships with friends.

They were allowed to check their own mobile

phone in order to retrospect the dialogues or the person who they chatted to and shared the information in a specific time or occasions.

7 Emoji means “picture letter” in Japanese. Each character has an official name, defined as part of the unicode standard.pictured characters.

Mobile phone placement during lectures and dependency on LINE and text messaging: Survey of students at a women's university in Japan

Keywords:
LINE messaging, text messaging, mobile phone dependency, classroom behavior, higher education

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Abstract

This study measured the dependency on text messaging of students in lectures at a women's university in Japan, comparing students who placed their mobile phone on their desk during lectures with those who did not do so. Dependency was measured by using a text-message dependency scale. Dependency on LINE messaging was measured by the same scale with "text" replaced by "LINE" in each question. The results of the questionnaire survey showed a significant difference in "emotional reaction," one of the three subscales of the scale used in the study, between students who placed their mobile phone on their desk and those who did not: the LINE messaging dependency score was higher among those who did. Also, in each subscale score and in the total of those scores, dependency on LINE messaging was significantly higher than dependency on text messaging for both students who placed their mobile phones on their desks during lectures and those who did not do so.

1. Introduction

Previous studies discussed the use of personal laptop computers during university lecture. Although these studies pointed out the negative effect of student laptop use during lectures, finding that it was a distraction from the lectures (Fang 2009; Fried 2008; Hembrooke and Gay 2003), different studies showed increased learning effectiveness through the appropriate use of laptops during lectures (Barak et al. 2006; Demb et al. 2004; Gay et al. 2001). In modern university lecture halls, the use of not only laptop computers but also of mobile phones (including smart phones) by students in lectures has also been frequently observed (Amali et al. 2012; Campbell 2006; Hammer et al. 2010; McCoy 2013; Wei and Wang 2010; Wei et al. 2012).

In the past, we saw almost no use of laptop computers by students in lectures at Japanese universities, as is seen in other countries, but the personal use of mobile phones by students during lectures was a common sight (Tachino et al. 2012). In the past, use of mobile phones by students during lectures was conducted "under the desk," that is, out of sight of the instructor (Matsushita 2007). However, we observed that the personal use of mobile phones by students during lectures has changed owing to the widespread use of smart phones, which was sparked in Japan by the introduction of the iPhone in 2008. In other words, the shift in the personal use of mobile phones to easy "on the desk" use was made possible by the fact that the backs of smart phones are flat and that the phones are usually operated by touchscreen. It cannot be said that the shape and design of smart phones is the sole cause for the change from hiding one's phone under the desk to using it on top, but it can be said that, at least as a background to this study, it is not difficult to find students using mobile phones on desks during lectures at Japanese universities in the present day.

Accordingly, we undertook an investigation of the use of mobile phones during lectures. In a preliminary investigation in which 21 Japanese university students participated, 52.4% of students responded that they "use mobile phones during lectures," and 42.9% of students said that they "don't feel embarrassed about operating mobile phones during lectures (Tachino et al. 2012)." In a study by Tachino et al. (2013a), a questionnaire was distributed to 20 students who placed their mobile phones on their desks during an exercise class in a computer lab room. The students were asked to answer two questions: a free response regarding the "reason for placing the mobile phone on the desk," and a yes or no question as to the "sense of guilt about placing a mobile phone on the desk." The results showed that the most common reason for placing a mobile phone on the desk, given by 7 students, was "for the purpose of receiving contact," and 9 of the students responded that they felt no sense of guilt about placing their phone on their desk (Tachino et al. 2013a). Also, in Tachino et al. (2013b) and Tachino et al. (2014), a yes/no questionnaire was given to 237 students, asking about their "experience of placing a mobile phone on the desk during lectures." Among respondents, 67.9% said that they placed their phone on their desk during regular lectures, and 30.8% said that they did so even in lectures where mobile phone use was prohibited (Tachino et al. 2013b; Tachino et al. 2014). The common finding of these preliminary investigations is that most university students who use mobile phones during lectures place their phones on their desks for the purpose

of using their phone as a communication tool.

Building on the preliminary investigations mentioned above, our current investigative study (Kato and Kato 2016) surveyed university about the use of mobile phones in lecture. The questionnaire began with a question regarding whether the student had their mobile phone placed on their desk "now" (from the time of distribution of the questionnaire to about 30 minutes after the beginning of the class). The analysis proceeded by grouping students according to the answer on that question and comparing the other responses between groups. The results of this study are given below. It was seen that the ratio of students who placed their mobile phone on their desk was 64.5% and that there was a higher probability among those who did so to use their phones during lessons to check phone, text, and LINE message content and to respond (by replying, etc.) to those messages; further, those who placed their phone on their desk felt more unease when rules restricting the use of mobile phones during classes were in place (Kato and Kato 2016). An additional pattern was seen: in mobile phone communication by students during classes, text-based communication was an easy choice. In particular, the LINE application, which is a (primarily smart phone-based) communication tool for free chat and voice over IP telephone calls, was used more often than standard mobile text messaging (Hereafter, "LINE messaging" will refer to LINE's chat function, called "Talk" in-app) (Kato and Kato 2016).

Although personal communication using mobile phones during classes differs from standard class behavior (Ling 2004), one reason this behavior occurs is because students desire the rapid exchange of mobile text messages (Kato et al 2012, 2013; Kato et al. 2013). Typically, a speedy response is desired in mobile text message communications. Students are aware that this expectation should be modified during classes. However, when there is pressure to not wait, or to keep others from waiting, until class has finished, and in situations where there are rules restricting the use of mobile phones, a sense of unease among students demonstrates a clear dependency on mobile text message communication. Yoshida et al. (2005) writes, (translated from Japanese) : "In recent years, the use of mobile phones without respect of time or place, and the prioritization of mobile text messaging over communication with others right in front of them, is becoming a significant dependency issue with mobile text messaging among young people."

Long hours of use was named as the primary cause of "Internet dependency" according to a 2013 Ministry of Internal Affairs and Communications survey targeting participants between upper primary school age and age 25 (Ministry of Internal Affairs and Communications, Japan 2014). According to the survey, 68.8% of high school students and 65.6% of university students responded that they had taken away from time dedicated for other activities in order to make more time for Internet use, mainly from sleeping (48.1% of high school students and 47.5% of university students) and study (46.6% of high school students and 34.6% of university students) (Ministry of Internal Affairs and Communications, Japan 2014). Many related studies point out that the existence of adverse effects on normal life activities is one possible indicator of dependency (Okada 2014). It has been noted that women are far more likely to use their mobile phones more than a PC, and that more women use mobile text

messaging and LINE (Ministry of Internal Affairs and Communications, Japan 2014). LINE, in particular, has been reported to be the most-used mobile communication tool (LINE Corporation 2013), particularly its chat, which is faster and easier to use for long periods of time than mobile text messaging (Kato 2015). Also, because LINE displays read receipts (a function that lets the sender know when his/her message has been read by the recipient), many young people continually check their phone to see if their messages have been read by the other party, in addition to normal use to send and receive messages. A previous study (Kato and Kato 2016) showed that LINE messaging is used more than text messaging in class, and as a result it is thought that dependency on LINE messaging is greater among students than dependency on other forms of text messaging. Because of the above, it is necessary to examine the degree of student Internet dependency as a factor in considering the personal use of mobile phones during lectures. Furthermore, consideration should be given to the main communication tools used in mobile text-based communication (mobile text messaging and LINE) within the overall scope of Internet dependency.

This study takes the student factor (dependency) into consideration in the personal use of mobile phones in lectures, but there are a variety of influences on student behavior. Many factors other than the student factor can be considered, such as lecture content, form of the lecture, the lecturer, and the classroom. However, moving students to an experimental setting wherein all of these factors are controlled for could cause students to alter their normal behavior. Therefore, the present study was conducted during a lecture at an actual university. Although in a real-life setting, students will be influenced by these various factors, intra-class comparison of students should allow for discernment of individual differences.

In certain types of classes, such as sports classes, multiple seminars, or classes where the lecturer strictly prohibits or punishes cell phone use in-class, external influences are too strong to confirm student factor. A survey by Terao and Ito (2014) reported that 40% to 60% of students used their mobile phones in lectures for personal reasons when no particular rules about mobile phone use in class were made. Because this is about the same as our abovementioned preliminary research, even though the classroom conditions may be different, the observation that about 50% of students are using their mobile phones during lectures (especially those in which no rules regarding phone use have been set) suggests that the relationships between the in-class factors and the students' behavior can be elucidated. Against this background, the present study was done in a class at a women's university confirmed to meet the above preliminary study requirements (Kato and Kato 2016). An all-female class was chosen to exclude the effects of gender.

Given the above, the present study examined the following two hypotheses.

Hypothesis 1: Due to the high probability of use of mobile phones during class by students who place their phone on their desk as compared with those who do not do so, there is a high degree of dependency on mobile text message communication among students who place their mobile phone on their desk during classes.

Hypothesis 2: Due to the trend for LINE text messaging to be used during classes, the degree of dependency on LINE text messaging among present-day female university students is greater

than that on mobile phone text messaging, another text communication tool.

2. Purpose

This study examined the relationship between the behavior of placing mobile phones on desks during university lectures and the dependency of university students on mobile text messaging and LINE. The dependency of students who placed their mobile phones on their desks during lectures was compared to students who did not. The aforementioned Hypothesis 1 and Hypothesis 2 were also examined.

3. Method

(1) Participants and Class Surveyed

This study was performed at a women's university in a liberal arts class on understanding media. This is an elective course, taken by first- to fourth-year students from various schools within the university. As a result, although small groups of three to five friends were seen, there was little overall social cohesion as is frequently seen in courses intended for specific majors. Enrolled students perform investigations on self-selected topics related to media and compile their findings into a PowerPoint presentation. In addition to general lectures, in each class approximately 10 of these presentations are randomly selected for the respective students to give 5-min presentations, which are then critiqued by the instructor and the rest of the class. This class was the same class surveyed in Kato and Kato (2016).

There were 101 students enrolled in the course, and the 80 participants (all Japanese women 18-21 years old, mean age 18.98 years ± SD 0.63 years) were the enrolled students in attendance on the day of the questionnaire.

The survey was performed in December 2013 during the eleventh class meeting, approximately 30 minutes after the class began. Students required approximately 15 minutes to complete the questionnaire. At the time of the questionnaire, no class rules were in place regarding the use of mobile phones.

(2) Questionnaire

The questionnaire distributed to student survey participants first required a "Yes or No" response to the question, "Is your mobile phone on your desk at the present moment?"

For the rest of the questionnaire, questions were used to measure dependency on mobile text messaging and LINE messaging. The text-message dependency scale of Yoshida et al. (2005) and Igarashi et al. (2008) was used to measure dependency on mobile phone text messaging. This scale incorporated an element of dependency on communication, taken from previous studies on Internet, computer, and mobile phone addiction (e.g., Armstrong et al. 2000; Block 2008; Caplan 2005; Griffiths 2000; Kandell 1998; Morahan-Martin and Schumacher 2000; Park 2005; Young 1998), and created from a comprehensive viewpoint of dependency on communication media (Igarashi et al. 2008; Yoshida et al. 2005). The full scale contains 56 items, but there is also a 15-item short-version scale (Igarashi et al. 2008, p.2318), and it was this short-version scale that was used in this study.

This scale is composed of 3 subscales. There are 5 questions in the "emotional reaction" subscale, such as "I feel disappointed if I don't receive any text messages," and "I often check my mailbox to see if I have a new text message."

There are 5 questions in the "perception of excessive use" subscale, such as "I sometimes send text messages while engaging in a conversation with another person," and "I sometimes spend many hours on text messages." There are also 5 questions in the "relationship maintenance" subscale, such as "I cannot maintain new friendships without text messages," and "I can't form any new relationships without using text messages." The questions require responses on a 5-point scale: not at all applicable, not very applicable, can't say either way, somewhat applicable, and very applicable.

To measure dependency on LINE text messaging, the phrase "text messages" was replaced by the phrase "LINE messages" in each of the 15 questions in the text-message dependency scale. For example, the phrase "I feel disappointed if I don't receive any text messages" for text-message dependency was changed to "I feel disappointed if I don't receive any LINE messages" for LINE text messaging.

Permission was obtained from the creators of the text-message dependency scale for the replacement of "text messages" with "LINE messages" in the text of each question.

4. Results

Responses to the question, "Is your mobile phone on your desk at the present moment?" showed that 67.5% (54 students) had their mobile phone placed on their desk (Figure 1). This group of 54 students is referred to as the "on-desk group" hereinafter, and the group of 26 students who answered negatively is called the "not-on-desk group."

Next, to compare the score for dependency on text messaging and LINE messaging between

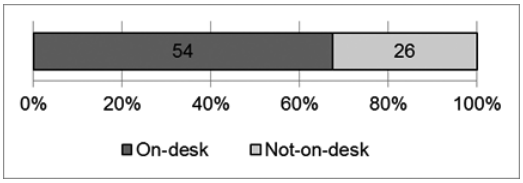

Figure 1 Number of students who placed their mobile phones on the desk during class

the two groups, an analysis of variance was performed with 2 factors, membership in the on-desk group (an intersubject or "group" factor) and dependency on mobile text messaging / LINE messaging (an intrasubject or "tool" factor).

Responses to the two dependency scale questions were on a 5-point scale and were analyzed as Likert items, with "Not at all applicable" given a value of 1 and "Very applicable" a value of 5. Additionally, there was 1 student in each group who reported that they do not use LINE messaging, and data for these 2 students were omitted from the analysis.

In the results of the analysis of variance using the total score of all 15 questions, the tool factor had a significant main effect (F (1, 76) = 45.50, p < .001), the group factor did not (F (1, 76) = 2.05), and the interaction was not significant (F (1, 76) = 0.95). Figure 2 shows that in both groups the dependency on LINE messaging was greater than the dependency on mobile text messaging.

An analysis of variance was also performed for the 3 subscale scores. Additionally, Cronbach's alpha was calculated for each subscale with the following results for text messaging and LINE messaging, respectively: 0.84 and 0.90 for emotional reaction, 0.73 and 0.83 for excessive use, and 0.91 and 0.85 for relationship maintenance.

In the results for the emotional reaction subscale, there were marked differences between

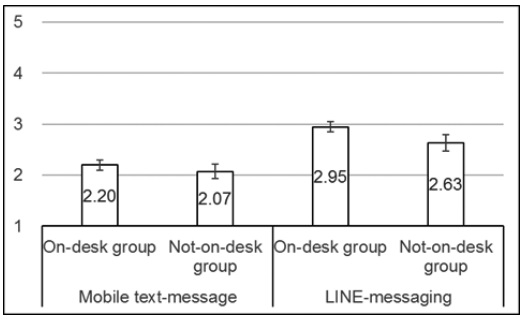

Figure 2 Comparison of average dependency scores between on-desk and not-on-desk groups

significances of the tool factor main effect (F (1, 76) = 30.58, p < .001), the group factor main effect (F (1, 76) = 3.30, p < .10), and the interaction effect (F (1, 76) = 3.03, p<.10). Figure 3 shows that in both groups, LINE-messaging dependency was higher than mobile text-message dependency, but that LINE-messaging dependency was even higher in the on-desk group.

For the perception of excessive use subscale, the tool factor main effect was significant (F (1, 76) = 58.63, p < .001), but the group factor main effect was not (F (1, 76) = 0.49) and there was no significant interaction (F (1, 76) = 0.00). Figure 4 shows that in both groups LINE-messaging dependency was higher than mobile text-message dependency.

For the relationship maintenance subscale, the tool factor main effect was significant (F (1, 76) = 13. 30, p < .001), but the group factor main effect was not (F (1, 76) = 0.63) and there was no significant interaction (F (1, 76) = 0.75). Figure 5 shows that in both groups LINE-messaging dependency was higher than mobile-text message dependency.

Finally, an analysis of variance was performed using the scores of each of the 5 questions for emotional reaction, where a difference in the group factor was observed. Significance was observed for each of the following 3 items. For "I

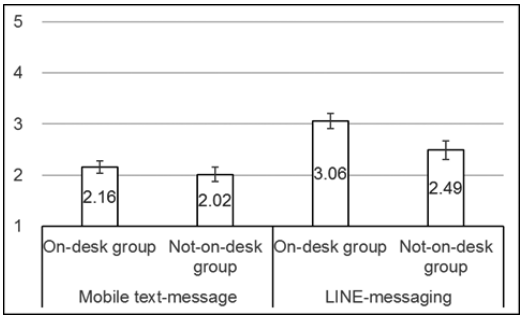

Figure 3 Comparison of average emotional reaction subscale scores between on-desk and not-on-desk groups

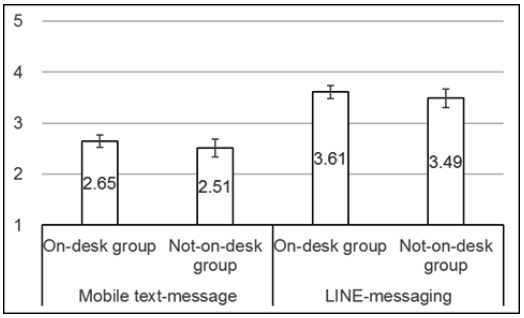

Figure 4 Comparison of average excessive use subscale scores between on-desk and not-on-desk groups

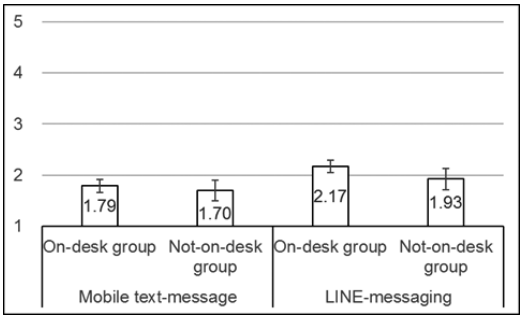

Figure 5 Comparison of average relationship maintenance subscale scores between on-desk and not-on-desk groups

feel disappointed if I don't receive any text messages / LINE messages", the interaction was significant (F (1, 76) = 4.90, p < .05) as were the tool factor main effect (F (1, 76) = 24.57, p < .001) and the group factor main effect (F (1, 76) = 3.48, p < .10). Figure 6 shows that for both groups LINE-messaging dependency was higher than mobile text-message dependency, but that LINE-messaging dependency was even higher in the on-desk group. For "I feel disappointed if I don't get a reply to my text message / LINE message immediately," the tool factor main effect was significant (F (1, 76) = 17.96, p < .001) as was the group factor main effect (F (1, 76) = 5.63, p < .05), but there was no significant interaction (F (1, 76) = 1.69). The item "I feel anxious when people don't immediately reply to my text message / LINE message" had the same pattern: a significant tool factor main effect (F (1, 76) = 14.22, p < .001) and group factor main effect (F (1, 76) = 5.38, p < .05), but an insignificant interaction (F (1, 76) = 0.85). The LINE-messaging dependency score was higher than the mobile text messaging dependency score, and both scores for the on-desk group were higher than those for the not-on-desk group (Figures 7 and 8).

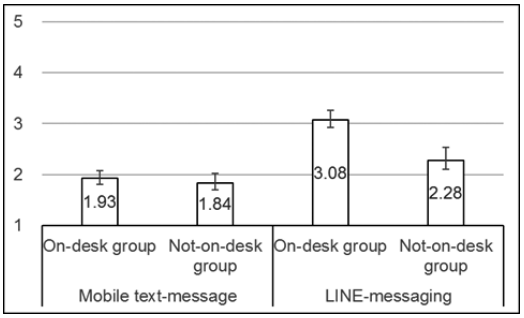

Figure 6 Comparison of average scores between on-desk and not-on-desk groups for the statement "I feel disappointed if I don't receive any text messages / LINE messages."

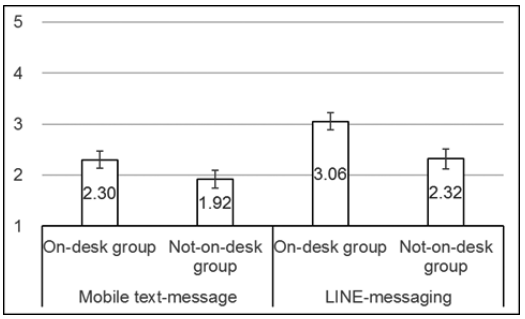

Figure 7 Comparison of average scores between on-desk and not-on-desk groups for the statement "I feel disappointed if I don't get a reply to my text message / LINE message immediately."

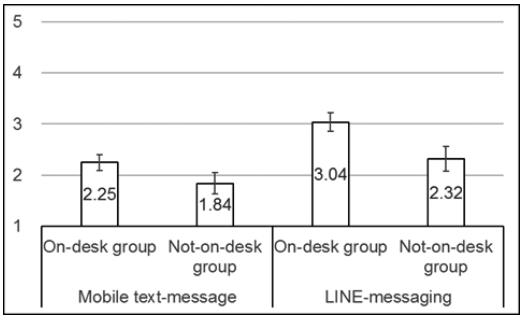

Figure 8 Comparison of average scores between on-desk and not-on-desk groups for the statement "I feel anxious when people don't immediately reply to my text message / LINE message."

5. Discussion

Using a questionnaire delivered to students of a women's university in Japan, dependency on LINE and text messaging was measured for students who placed their mobile phones on their

desk during class and those who did not do so, and two hypotheses were examined.

The first hypothesis, that there is a high degree of dependency on mobile text message communication among students who place their mobile phone on their desk during classes, is partly supported. A difference in score was observed between the on-desk and not-on-desk groups in only the emotional reaction subscale of dependency on LINE messaging, with the on-desk group having a higher score. Among the 3 subscales, the score for perception of excessive use was highest in both groups for both mobile phone text messaging and LINE messaging. Excessive use indicates extended periods of continuous mobile text messaging and LINE messaging, and the use of mobile text messaging and LINE messaging in communicating back and forth with people as well. In contrast, the relationship maintenance subscale, which asked about the necessity of mobile text messages and LINE messages to create and maintaining personal relationships, was lowest among the subscales for both groups. Taken together, these imply that university students use mobile text messaging frequently but do not think that personal relationships are impossible to create and maintain without mobile text and LINE messaging. It was also observed that students who place their phone on their desk during class have a marked tendency to feel lonely or uneasy when they do not receive a quick reply from the other party during their communication, but this emotional reaction was more apparent for LINE messaging than in mobile text messaging.

The second hypothesis, that the degree of dependency on LINE text messaging among university students is greater than that on mobile phone text messaging, is supported. LINE text communication is a form of chatting. That is, because LINE messages are regarded as more casual, daily conversation (with messages exchanged simultaneously and continuously), the perception of excessive use score was higher for LINE messaging than for mobile text communication. As regular conversation creates and maintain personal relationships, it was expected that the relationship maintenance score would be slightly higher for LINE messaging, which enables conversation-style exchanges more readily than mobile text messaging does. Additionally, LINE messaging notifies the sender when a message has been read. This means that, in addition to waiting for a reply that is not arriving quickly, which occurs with mobile text messaging, LINE messaging also causes users to wait for a reply that is not arriving quickly even though the sender that knows the recipient has read the message. Thus the emotional reactions of loneliness and unease arise more easily with LINE messaging.

According to LINE Corporation (2013), most LINE users are in their teens and twenties, with the amount dropping for those 30 and older. While most university students use LINE to communicate with students of the same generation, most members of the older generation use standard mobile text messaging, mainly because they are not as accustomed to the newer communication tool as younger students (Kato 2015). Thus, the parties involved when communicating by LINE are different from those in mobile text messaging. Because for most university students, familiar people such as friends, significant others, and so on are generally in the same generation, it is assumed that they use LINE to communicate with these parties and mobile text messaging to communicate with out-

of-generation individuals such as superiors at work or parents. If parties are different, the message content will also differ: in LINE, the content is mainly conversation that includes a variety of emotional expressions, while in mobile text messaging the content is more likely to be mainly business-like exchange. Compared with mobile text messaging, the use ratio of LINE is therefore increasing, with LINE taking on an important role in the deepening of relationships such as friendships. Because of this, it is thought that there are many more messages received in LINE and that the attention paid to replies and whether messages have been read or replied to has contributed to increased dependency on LINE.

This study was conducted in a classroom where no rules had been set regarding mobile phones. However, this didn't completely remove differences in influence between students. For example, we assume that differences in student's seating were influential. Generally speaking, if the seat in front of you is occupied, it's easier to take out your mobile phone without being seen by the lecturer. This can be described as an external influence on the placing of a phone on the desk. However, several student factors other than dependency can also be considered, such as difference in student age. First-year students may still experience residual influences from mobile phone rules in high school, which are generally very strict. Also, individual differences between students may also become factors, such as student relationships and events taking place that day (such as an emergency call, or having just received a romantic confession). This study, however, demonstrated and clarified that there are a number of correlations between the behavior of setting phones on desks in lectures and dependency scale score, although it goes without saying that future studies should investigate the various external and internal influences on phone behavior.

6. Conclusions

This study examined the relation between dependency on mobile text messaging and LINE messaging and the act of placing a mobile phone on the desk during classes, focusing on students at a Japanese women's university.

1) Students who place their mobile phone on their desk have a particularly high dependency score for LINE messaging for emotional reactions, including feelings of uncertainty and loneliness in waiting for a slow reply.

2) There is a higher dependency score for LINE messaging than for mobile text messaging.

This study focused on the act of university students placing their phone on their desk during classes. Our previous study showed that the act of placing a mobile phone on one's desk is a sign that shows the potential for mobile phone use during classes (Kato and Kato 2015). According to this study, this action also suggests a high degree of dependency on mobile phone use by the student.

7. Limitations and future research

The number of samples in this study was 78, so consideration remained focused on classification of whether students did or did not place their mobile phones on their desk. In the future, it will be necessary to conduct this same survey under the same conditions, but with an increase sample size, to improve the quantity of data. By doing so, it will become possible to classify phone use

according to common student attributes (e.g. academic year, major, seat that day, frequency of mobile text messaging / LINE use, purpose of use) and consider the influence of these attributes in more detail. Furthermore, adding data on various lecture factors will enable multivariate analysis to include external attributes, improving our understanding of the relative strengths and weaknesses of a variety of influences.

Modern university students are often called "digital natives," indicating a generation that has been born and educated in an environment where they are surrounded by computers and mobile phones, and it is said that they are skilled at multitasking (Prensky 2001a, 2001b). A detailed examination of the effects of mobile phone use during classroom lectures should be conducted to test this assertion (Baron 2008).

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An Evaluation of Measures against the Urban Heat Island from the Viewpoint of Artificial Exhaust Heat of Road Traffic*
– An Evaluation Using GIS in the Tokyo 23-Ward Area –

Keywords:
Urban Heat Island, Artificial Exhaust Heat, Road Traffic, Geographic Information Systems (GIS), Tokyo 23-Ward Area

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Abstract

This study aims to evaluate measures against the Urban Heat Island (UHI) from the viewpoint of artificial exhaust heat of road traffic using Geographic Information Systems (GIS) in the Tokyo 23-Ward Area where the degree of UHI is particularly strong. We developed a GIS database that reflects road traffic conditions and calculated the volume of artificial exhaust heat of road traffic to evaluate measures against the UHI.

The findings of this study can be summarized in the following three points.

(1) Artificial exhaust heat volume for moving targets was remarkably higher than that of stationary targets and, in particular, artificial exhaust heat volume was high on roads with remarkable numbers of vehicles and running speeds such as expressways and ring roads. Artificial exhaust heat volume was particularly high for cars and regular trucks by model, and for weekdays and holidays, and daytime and night-time, artificial exhaust heat volume was mainly high during the day on weekdays.

(2) In UHI-related policy for moving targets, the suppression of waste heat through choice of fuel burned, improvement of traffic flow by securing space for cyclists and pedestrians, development of bypasses, and upgrading signal control managed to reduce artificial exhaust heat volume even though there were differences in degree of reduction. However, roads with high artificial exhaust heat volume reduction ratio differed with each UHI-related policy.

(3) In UHI-related policy for stationary targets, special road surfaces and the increase in efficiency of energy consumption equipment achieved a reduction ratio of around 30% in artificial exhaust heat volume, more than moving targets as well as making it possible to expect a reduction in artificial exhaust heat volume on a wide scale.

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1. Introduction

1.1 Point of view and purpose of research

Due to global warming in recent years, Urban Heat Islands (UHI) have become a serious problem for major urban areas in every country of the world. Japan's Inter-Ministry Coordination Committee to Mitigate Urban Heat Island developed the Outline of the Policy Framework to Reduce Urban Heat Island Effects in 2004. The Ministry of Economy, Trade and Industry (2007) reported that Japan's energy consumption in the private consumer, transportation and industrial sectors increased by approximately 2.6, 2.1 and 1.0 times respectively from 1973 to 2005. The Ministry of the Environment (2003a) also reported an increasing trend in artificial exhaust heat due to energy consumption in the Tokyo 23-Ward Area, and suggested that the proportions of artificial exhaust heat were approximately 50% buildings, 40% automobiles and 10% factories.

Mikami (2005) suggests changes in urban structure and artificial exhaust heat as causes for UHI, while the Japanese Meteorological Agency (2007) suggests changes in land use, the effects of buildings and the effects of artificial exhaust heat. Though the highest proportion of artificial exhaust heat is caused by buildings, measures to increase natural ground cover and greenery have already been implemented, and there are many examples of UHI research related to city green zones and increasing greenery for buildings and their grounds represented by Hirano et al. (2004) and Hoyano (2005). However, the proportion of artificial exhaust heat caused by road traffic in the field of transportation, in particular automobiles, is high and despite this being one of the major causes of UHI, there has been little focus on this issue.

Based on the above, this study targets the Tokyo 23-Ward Area where UHI intensity is particularly high, using a Geographic Information System (GIS) [(1)] with the aim of evaluating UHI-related policies focusing on artificial exhaust heat from road traffic. According to the Tokyo Metropolitan Heat Island Mitigation Committee (2003), recorded temperatures in the Tokyo 23-Ward Area have risen by approximately 3℃ in the past 100 years, and due to the fact that this rise is high in comparison with other large cities in Japan and other countries, it is understood that UHI intensity as urban warming is remarkably high in addition to the effects of global warming.

1.2 Related Work

The first study on UHI to be published in Japan was Tyson et al. (1973), and the number of studies began to increase dramatically from around the year 2000. Based on the results of a review of prior research targeting the relationship between UHI and artificial exhaust heat in the same way as this study, the following 16 major studies were divided into 4 groups depending on their research targets.

(1) Phenomenon / characteristics (3 studies): Mikami (2002), Ashie et al. (2004), Ishimaru (2004)
(2) Causes / mechanism (1 study): Mikami (2005)
(3) Effects / issues (7 studies): Mochida et al. (2001), Yoshida et al. (2002a, 2002b), Kamishige (2004), Sugahara (2005), Tamura et al. (2006b), Narumi (2006)
(4) Measures / effects (5 studies): Ota (2001), Tamura et al. (2003, 2005a, 2005b, 2006a)

As shown by the above prior research in related fields, though (3) Effects / issues have been most frequently studied, there have been

few studies on the relationship between UHI and the artificial exhaust heat from road traffic. Only Ashie et al. (2004) discussed the differences between sensible heat and latent heat, and calculated artificial exhaust heat output for road traffic in 500m grid units in the Tokyo 23-Ward Area using GIS to obtain an understanding of the output characteristics of artificial exhaust heat. Though Ashie et al. (2004) conducted analysis in 500m grid units, it did not specifically investigate to propose UHI mitigation, or a detailed understanding of artificial heat volume considering road traffic status.

Accordingly, this study refers the results of the above-mentioned prior research as a foundation, and highly effective GIS as a database development and information analysis tool to develop a digital map database reflecting the status of road traffic. Furthermore, using this, specific evaluation of UHI-related policy is conducted after calculating artificial exhaust heat volume from road traffic for each road unit using GIS.

2. Evaluation method

2.1 Evaluation framework and method

This study began with a review of prior research to gather UHI-related policy with reference to artificial exhaust heat from road traffic in the Tokyo 23-Ward Area, and organized this information focusing on the characteristics of each policy target. Effect functions were set in order to analyze the effects of UHI-related policy after implementation, taking road traffic status into account, and road traffic status data and function coefficients used government data, experiment results and estimated values.

Using the above method, if all data and research information is updated using future technology developments and advances in research, it will be possible to update and provide even more accurate information. In addition, though this study targeted the Tokyo 23-Ward Area, if it were possible to obtain the same kind of data and information, it would be possible to conduct evaluation by applying this evaluation method to other urban areas. Due to this, we can expect the evaluation method proposed in this study to be temporally and spatially general-purpose and duplicable.

Next, this study set initial functions prior to the implementation of each UHI-related policy and effect functions for post-policy implementation, suggested respective methods of calculating artificial exhaust heat volume before and after policy implementation using GIS, and used these to calculate artificial exhaust heat volume. Furthermore, by comparing artificial exhaust heat volume before and after the implementation of each UHI-related policy, evaluation was conducted by investigating the effects of implementation of each policy. Though it should be noted that Ashie et al. (2004) conducted analysis in 500m grid units as mentioned above, this study used a digital base map that expresses roads in line format as detailed in the section below to add diverse data, and develop an integrated database to analyze and evaluate. By doing this, it was possible to calculate artificial exhaust heat volume by road unit and evaluate UHI-related policy, taking road traffic status characteristics into account.

2.2 GIS database development / usage process

Figure 1 shows the development / usage process for the GIS database in this study. First of

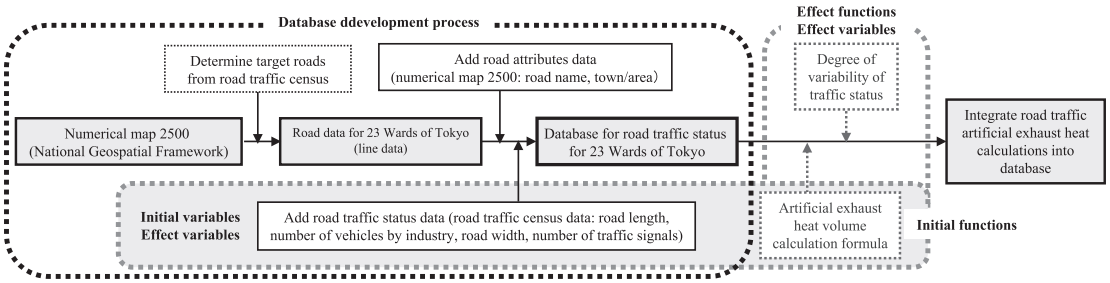

Figure 1 GIS Database Development / Usage Process

all, road data was developed in digital map format from 42,461 lines with numerical map 2500 (National Geospatial Framework)[2]. Next, this data was added to / integrated with data relating to the road attributes and road traffic status on road traffic census[3] and numerical map 2500 to develop a database of road traffic status in the Tokyo 23-Ward Area.

Furthermore, from the next section onwards, following the framework and method explained in the previous section, the volume of artificial exhaust heat before and after implementation of each UHI-related policy was calculated using GIS, and this data was also integrated into the road traffic status database. It should be noted that initial and effect variables for road traffic status data, effect variables for degree of variability of traffic status and the artificial exhaust heat volume calculation formula included in initial and effect functions in Figure 1 are shown in section 3. Section 4 shows the concrete artificial exhaust heat volume calculation method using GIS in a flow chart and calculates artificial exhaust heat volume.

3. Organization of UHI-related policy and setting of functions

3.1 The relationships between the organization of UHI-related policy and functions

All policies listed by the Ministry of the Environment (2003b), the Tokyo Metropolitan Heat Island Mitigation Committee (2003), and the Ministry of Land, Infrastructure, Transport and Tourism (2007) were researched, and the nine policies shown in Table 1 are the result of extracting only UHI-related policies that were implemented or under consideration for the mitigation of artificial exhaust heat from road traffic in the Tokyo 23-Ward Area. Furthermore, the authors focused on the characteristics of each policy target, and divided to organize these into three groups: A. Transport framework / fuel, B. Road / road surface construction, and C. Road equipment. It should be noted that UHI-related policies No.3, 4, 5, 7 and 8 aimed to improve running speed by alleviating and reducing traffic congestion during the day.

Though the effects of implementation of related policies are diverse, they do permit eventual effects that inhibit artificial exhaust heat (main effects). Accordingly, primary factors directly before achieving main effects were defined as supplementary effects, and the

determinants of supplementary effects were determined as effect variables. Effect functions were set and calculations were made for artificial exhaust heat volume affected by the supplementary effects of each related policy using these effect variables. As shown in the previous section, initial functions were also set before the implementation of these policies in order to obtain an understanding of the implementation effects of each UHI-related policy.

It was possible to divide supplementary effects into four categories: improvements in fuel consumption, improvements in running speed, reduction in heat storage volume, and increase in efficiency of equipment. Furthermore, the targets of supplementary effects were divided into two groups: moving and stationary depending on whether the target is traffic flow data (number of vehicles, running speed) or traffic facility data (road length or width, number of traffic signals).

Using the above-mentioned method, it was possible to specify how effects are emphasized by the supplementary effects of each related policy, and to organize data categories in road traffic status data which is an effect variable and degree of variability of traffic status for each UHI-related policy. As moving targets were mainly affected by sensible heat and stationary targets by latent heat, it can be said that the categories in

Table 1　UHI-Related Policy and Effect Variables

Policy target		Policy	UHI-related policy	Supplementary effects	Effect Target	Effect variables (road traffic status data / degree of variability in traffic status)				
						Road Length	Number of Vehicles	Running Speed	Road Width	Number of Traffic Signals
A.	Transport framework/Fuel	No.1	Spread of low-emission vehicles (hybrid)	Improvements in fuel consumption	Moving Targets	○	Diffusion rate	○	×	×
		No.2	Suppression of waste heat through choice of fuel burned (bioethanol)	Improvements in fuel consumption		○	Diffusion rate	○	×	×
B.	Road/Road surface construction	No.3	Improvement of traffic flow by securing space for cyclists and pedestrians	Improvements in running speed		○	○	Progress rate	×	×
		No.4	Development of bypasses	Improvements in running speed		○	○	Progress rate	×	×
		No.5	Improvement of access roads to airports and ports	Improvements in running speed		○	○	Progress rate	×	×
		No.6	Special road surfaces (water-holding surfaces)	Reduction in heat storage volume	Stationary Targets	○	×	×	○	×
C.	Road equipment	No.7	Increase in efficiency of energy consumption equipment (changing signal lights to LED)	Increase in efficiency of equipment		×	×	×	×	Diffusion rate
		No.8	Upgrading signal control	Improvements in running speed	Moving Targets	○	○	Progress rate	×	×
		No.9	Diffusion of ETC	Improvements in running speed		○	Diffusion rate	Progress rate	×	×

1) The ○ symbol in the table represents road traffic status data which is an effect target for supplementary effects in each UHI-related policy, and each value for road traffic status data and degree of variability in traffic status (diffusion and progress rates) marked with ○ is used to calculate artificial exhaust heat volume. The × symbol represents road traffic status data which is not an effect target for supplementary effects in each UHI-related policy.

2) UHI-related policies No.1 and No.2 are both UHI policies related to automobiles. According to the Ministry of the Environment (2003b), the Tokyo Metropolitan Heat Island Mitigation Committee (2003), and the Ministry of Land, Infrastructure, Transport and Tourism (2007), hybrid vehicles with two sources of power in the engine and in the motor, and driven using a combination of their respective benefits are defined as vehicles that can achieve both energy conservation and low emissions. Policy No.1 targets only hybrid vehicles, whereas policy No.2 targets vehicles that run on gasoline, excluding hybrid vehicles.

this study considers the effects of both sensible and latent heat.

3.2 Setting initial functions

Table 2 provides an overview of initial functions, while Table 3 provides an overview of initial variables. A formula for calculating artificial exhaust heat volume in initial functions such as those in Table 2 was developed according to the two categories mentioned above, moving and stationary targets. Using this formula, a basic structure was formed to group effect functions calculating artificial exhaust heat volume after the implementation of each UHI-related policy. It should be noted that, as elements of effect functions were designated as effect variables, in the same way, elements of initial functions were designated as initial variables. Initial variables are: road traffic census road traffic status data, waste heat coefficients by model and speed converted from the energy consumption coefficients by model and speed which are provided by Ministry of Land, Infrastructure, Transport and Tourism / Ministry of the Environment [4], road surface waste heat coefficients in the results of Kanto Regional Development Bureau, the Ministry of Land, Infrastructure, Transport and Tourism [5] project, and traffic signal waste heat coefficients converted to one day's worth of heat volume from electricity consumption by light bulb and LED from the National Police Agency [6].

Table 2 shows each data category for road traffic status data used as initial variables, and these are also used in the same way in effect functions detailed in the next section. Road traffic census values were used in each of the above-mentioned categories, and values for numbers of cars, buses, and small and regular trucks were input by model and running speed values for both weekdays and holidays in FY2005 were input. For the number of traffic signals, the number of intersections with traffic signals was calculated by dividing them into two types depending on the width of the road: main roads and minor roads, and the number of traffic signals was set at four as the average number found at a regular cross-shaped intersection and

Table 2 Initial Functions

Initial target	Initial function (Artificial exhaust heat volume calculated formula) Q_α, Q_β[J]
Moving target	Q_α=road length L[km]×number of vehicles by model M[number]×waste heat coefficient by model/speed C_v[J/(km・number)]
Stationary target	Q_β=(road length L[km]×road width W[km]×road surface waste heat coefficient C_{lw}[J/km^2])+ (number of traffic signals S[number]×traffic signal waste heat coefficient C_s[J/number])

Table 3 Outline of Initial Variables

Effect target	Initial variables	Explanation	Source
Moving target	Waste heat coefficient by model speed C_v [J/(km・number)]	Convert with waste heat by model 4.1858[kJ/kcal] per source speed	Ministry of Land, Infrastructure, Transport and Tourism / Ministry of the Environment (2004) Survey of Heat Island Mitigation through Artificial Exhaust Heat Control in Urban Areas 2003 <http://www.mlit.go.jp/sogoseisaku/heat_island/05.pdf>
Stationary target	Road surface waste heat coefficient C_R[J/m^2]	Asphalt road surface temperature set at 63[℃] 【Test value】 (1 day's worth of waste heat volume 6.24×10^4[kJ/m^2] according to the Stefan-Boltzmann Constant)	Kanto Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism (2004) The Challenge of alleviating the Heat Island Phenomenon on Roads - Results of the Tokyo Environmental Surface Project (press conference documents, 25th May, 2004)
	Number of traffic signals S[number]	Number of traffic signals per intersection set at 4	Japan Society of Traffic Engineers Results of Responses to Enquiries to Road Traffic Census Support Staff 2005
	Traffic signal waste heat coefficient C_L[J/number]	Bulbs used determined as 70W 【Document value】 (1 day's worth of waste heat 6.0×10^3[kJ/number])	National Police Agency Conversion of Traffic Signals to LED <https://www.npa.go.jp/koutsuu/kisei/shisetu/led.pdf>

calculations were made.

3.3 Setting effect functions

Table 4 provides an overview of effect functions, while Table 5 provides an overview of effect variables. Effect functions such as those in Table 4 were composed using effect variables and in effect variables, there were functions for which degree of variability of traffic status was added to road traffic status data as shown in the previous section as a correction factor after the implementation of each UHI-related policy. Moreover, there were also functions for which heat waste coefficient by model / speed, road surface waste heat coefficient, and traffic signal waste heat coefficient were each converted respectively.

Degree of variability of traffic status effect variables was set as a correction factor in order to reflect the effects of the implementation of each UHI-related policy in each data category of road traffic status data. These are the actual changing values at the time of setting effect functions in order to calculate artificial exhaust heat volume after the implementation of each policy. If there are changes to the expected implementation effects of UHI-related policies, it is possible to recalculate artificial exhaust heat volume by re-setting this degree of variability for traffic status.

Moreover, waste heat coefficients by model / speed in initial functions were re-set in moving target UHI-related policies No.1, 2, 3, 4, 5, 8 and 9 as waste heat coefficients by model / speed in effect functions. This is because the policy target in UHI-related policies No.1 and 2 is related to A. Transport framework / fuel, and there is potential for future change in goal values for waste heat volume, waste heat rate and rate of spread of target vehicles. This is because, in UHI-related policies No.3, 4, 5, 8 and 9, corrected values for running speed in road traffic status data through improvement of degree of variability in traffic

Table 4　Effect Functions

Policy	UHI-related policy	Effect target	Effect function (Artificial heat exhaust volume calculation formula) Qn[J]
No.1	Spread of low-emission vehicles (hybrid)	Moving targets	Q_1＝road length L[km]×〔(diffusion rate d_1[%]×number of vehicles by model M[number]×waste heat variables by model/speed X_{Cv1}[J/(km・number)])＋{(100-diffusion rate d_1[%])×number of vehicles by model M[number]×waste heat coefficients by model/speed C_v[J/(km・number)]}〕
No.2	Suppression of waste heat through choice of fuel burned (bioethanol)		Q_2＝road length L[km]×〔(diffusion rate d_2[%]×number of vehicles by model M[number] waste heat variables by model/speed X_{Cv2}[J/(km・number)])＋{(100-diffusion rate d_2[%])×number of vehicles by model M[number]×waste heat coefficients by model/speed C_v[J/(km・number)]}〕
No.3	Improvement of traffic flow by securing space for cyclists and pedestrians		Q_3＝road length L[km]×noumber of vehicles by model M[number]×waste heat variables by model/speed X_{Cv3}[J/(km・number)]
No.4	development of bypasses		Q_4=road length L[km]×number of vehicles by model M[number]×waste heat variables by model/speed X_{Cv4}[J/(km・number)]
No.5	Improvement of access roads to airports and ports		Q_5＝road length L[km]×number of vehicles by model M[number]×waste heat variables by model/speed X_{Cv5}[J/(km・number)]
No.6	Special road surfaces (water-holding surfaces)	Stationary targets	Q_6＝road length L[km]×road width W[km]×road surface waste heat variables X_{CIW}[J/km^2]
No.7	Increase in efficiency of energy consumption equipment (changing signal lights to LED)		Q_7＝number of traffic signals S[number]×〔{LEd diffusion rate d_7[%]×traffic signal waste heat variables X_{CL}[J/number]}＋{(100-LED diffusion rate d_7[%])×traffic signal waste heat coefficients C_L[J/number]}〕
No.8	Upgrading signal control	Moving targets	Q_8＝road length L[km]×number of vehicles by model M[number]×waste heat variables by model/speed X_{Cv8}[J/(km・number)]
No.9	diffusion of ETC		Q_9＝road length L[km]×〔(diffusion rate d_9[%]×number of vehicles by model M[number]×waste heat variables by model/speed X_{cv9}[J/(km・number)])＋{(100-diffusion rate d_9[%])×number of vehicles by model M[number]×waste heat coefficients by model/speed C_v[J/(km・number)]}〕

Table 5 Overview of Effect Variables

Policy	Effect variables	Explanation	Source
No.1	Waste heat variables by model/speed X_{Cv1}[J/(k・number)]	cars/buses: waste heat ratio of 75% as hybrid vehicles【Assumed value】 small/regular trucks: waste heat ratio of 74% as CNG trucks【Assumed value】	Ministry of Land, Infrastructure, Transport and Tourism (2005) Ranking by Vehicle Weight <http://www.mlit.go.jp/kisha/kisha05/09/090223/02.pdf>
	Diffusion rate d_1[%]	Target vehicles are 0.87% of all vehicles (figures from the year 2000)	Japan Automobile Manufacturers Association (2001) Special Report on the Development and Spread of Low-emission Vehicles <http://www.jama.or.jp/lib/jamagazine/200109/01.html>
No.2	Waste heat variables by model/speed X_{Cv2}[J/(km・number)]	60% waste heat using E100【Assumed value】	Council for Science, Technology and Innovation, Cabinet Office, Government of Japan Roadmap and Diffusion Scenario for Environmental Energy Technology <http://www8.cao.go.jp/cstp/siryo/haihu75/sanko2-1.pdf>
	Diffusion rate d_2[%]	Target vehicles are 42% of gasoline vehicles (gasoline vehicle ratios/cars: 88.7%, buses: 0.28%, small/regular trucks: 24.6%)	Daiwa Institute of Research (2007) New Industry Report 2007/summer: Trends in Automobile Technology borne by the Next Generation <http://www.dir.co.jp/souken/research/report/emg-inc/hitech/07060101hitech.pdf> Ministry of Land, Infrastructure, Transport and Tourism, Policy Bureau Information Management Division (2006) Outline of Traffic-related Energy <http://www.mlit.go.jp/toukeijouhou/energy/h18_energy.pdf>
No.3	Waste heat variables by model/speed X_{Cv3}[J/(km・number)]	Improve running speed for all vehicles by 10% except on national/urban expressways【Simulation value】	Yuichi Harumoto (2006) Understanding of the Current Status of Urban Traffic and Bicycle Use in Nagano City <http://taklab12.shinshu-u.ac.jp/contents/subjects/Others/pdf/B4_harumoto.pdf>
No.4	Waste heat variables by model/speed X_{Cv4}[J/(km・numner)]	For roads (congested roads) with running speed of 20[km/h] or less, running speed is set at 21[km/h] as a congestion solution value【Assumed value】	Inter-Ministry Coordination Committee to Mitigate Urban Heat Island (2004) Outline of the Policy Framework to Reduce Urban Heat Island Effects <http://www.env.go.jp/air/life/heat_island/taikou.pdf> Ministry of Land, Infrastructure, Transport and Tourism Kanto Regional Development Bureau Alleviating Traffic Congestion <http://www.ktr.mlit.go.jp/3kanjo/efficacy/traffic_jam.htm>
No.5	Waste heat variables by model/peed X_{Cv5}[J/(km・number)]	For roads with running speed of 20[km/h] or less, such as coastal roads (national highways 14 and 357, coastal expressways) and the Yokohama-Haneda Airport urban expressway, running speed is increased by 13% as a congestion alleviation value 【Current congestion alleviation value】	Tokyo Metropolitan Government (2000) Basic Aviation Policy (enhancement/strengthening of access to 4 airports) <http://www.toshiseibi.metro.tokyo.jp/kanko/ksk/03-4.pdf> Ministry of the Environment (2007) (Annex) State of Progress of Specific Policies recorded in the Outline of the Policy Framework (July, 2007 Ministry of the Environment press conference documents) <http://www.env.go.jp/press/file_view.php?serial=9863&hou_id=8588>
No.6	Road surface waste heat variable X_{CR}[J/km^2]	Set at 40℃ using water-holding surfaces【Test value】 (1 day's worth of waste heat volume 4.70×10^4[kJ/m^2] according to the Stefan-Boltzmann Constant)	Ministry of Land, Infrastructure, Transport and Tourism, Kanto Regional Development Bureau (2004) The Challenge of alleviating the Heat Island Phenomenon on Roads - Results of the Tokyo Environmental Surface Project (press conference documents, 25th May, 2004)
No.7	Traffic signal waste heat variables X_{CL} [J/number]	Set at 15W using LED【Document value】 (1 day's worth of waste heat volume 1.3×10^3[kJ/number])	National Police Agency Conversion of Traffic Signals to LED <https://www.npa.go.jp/koutsuu/kisei/shisetu/led.pdf>
	LED diffusion rate d_7[%]	LED diffusion rate was set at 39.4% (Rate of use of LED in vehicles in Tokyo) (Number of traffic signals at 1 intersection was set at 4)	National Police Agency Number of Instances of Maintenance in Traffic Signals by Prefecture <https://www.npa.go.jp/koutsuu/kisei/institut/kazu.pdf>
No.8	Waste heat variables by model/speed X_{Cv8}[J/(km・number)]	Improve running speed for all vehicles by 10% excluding national expressways, urban expressways and minor roads with no traffic signals 【2007 Goal Values for the Policy Framework to Reduce Urban Heat Island Effects】	Ministry of the Environment (2007) (Annex) State of Progress of Specific Policies recorded in the Outline of the Policy Framework (July, 2007 Ministry of the Environment press conference documents) <http://www.env.go.jp/press/file_view.php?serial=9863&hou_id=8588>
No.9	Waste heat variables by model/speed X_{Cv9}[J/(km・number)]	For national and urban expressways which are roads (congested roads) with running speed of 20[km/h] or less, running speed is increased to 13% as a congestion alleviation value【Current congestion alleviation value】	Ministry of the Environment (2007) (Annex) State of Progress of Specific Policies recorded in the Outline of the Policy Framework (July, 2007 Ministry of the Environment press conference documents) <http://www.env.go.jp/press/file_view.php?serial=9863&hou_id=8588>
	Diffusion rate d_9[%]	75.8% of all vehicles are target vehicles (national figure as of December, 2008)	Ministry of Land, Infrastructure, Transport and Tourism (2008) Status of Usage of ETC (bulletin) (as of 18th December, 2008) <http://www.mlit.go.jp/road/yuryo/riyou.pdf>

status at the time of composing effect functions are inherent as heat waste variables by model and speed. Furthermore, road surface waste heat coefficients in initial functions were reflected in the implementation effects of each policy as road surface heat waste variables in effect functions, and traffic signal waste heat variables in the same way in traffic signal waste heat coefficients, and each artificial exhaust heat volume was re-defined. UHI-related policy No.3 was based on research results in the centre of Nagano City, and as a result of reviewing research such as data

from governmental documents, experiment results and estimated values relating to the effect functions of the policies mentioned in 2.1, at present, this study determined that its own research target areas were the most appropriate.

4. Calculation of artificial exhaust heat volume using GIS

4.1 Artificial exhaust heat calculation method

Figure 2 shows the artificial exhaust heat volume calculation method using GIS in flow chart format. First of all, initial variables were set

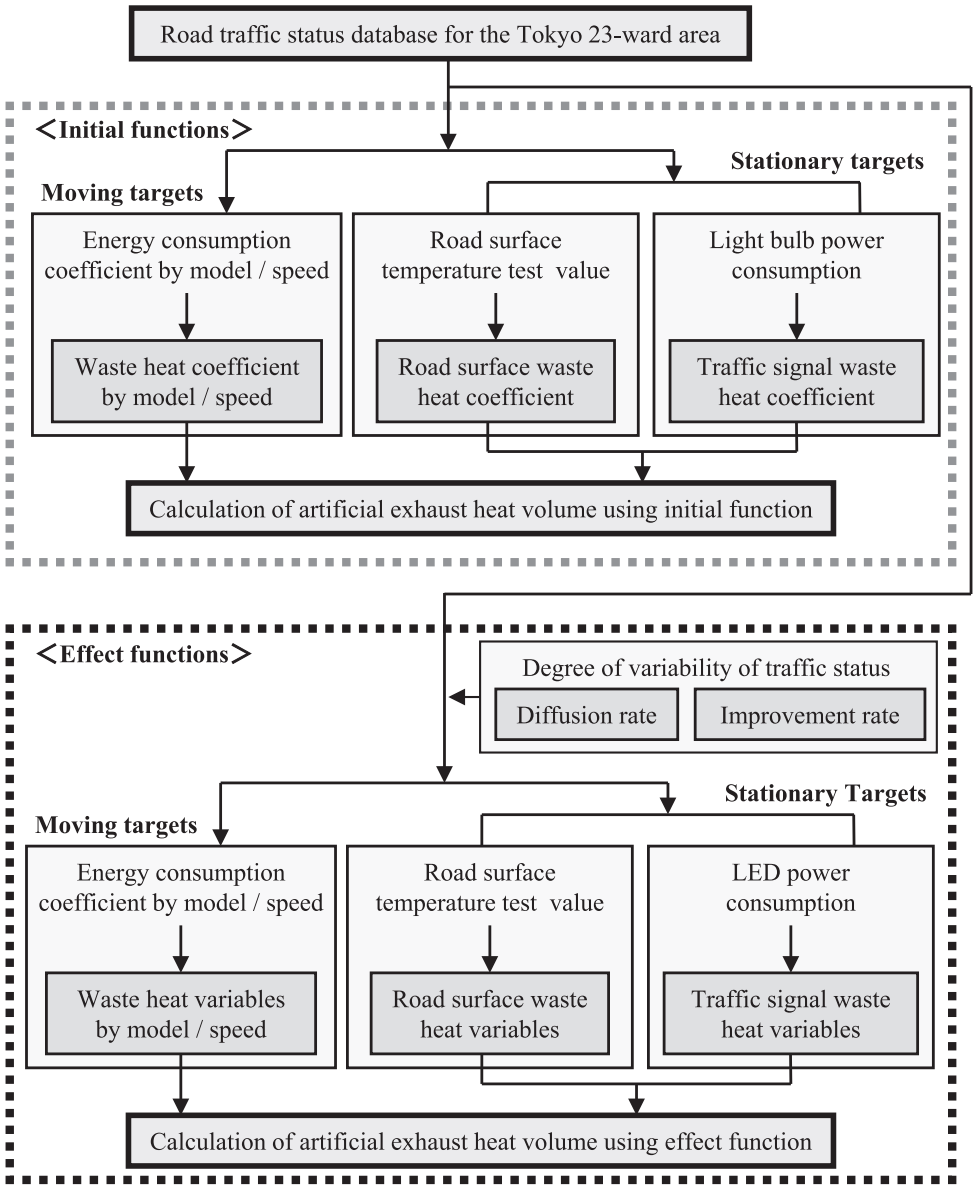

Figure 2 Calculation Method for Artificial Exhaust Heat Volume using GIS

as heat waste coefficients by model and speed for moving targets, and as road surface heat waste coefficients and traffic signal waste heat coefficients for stationary targets in initial functions. Artificial exhaust heat volume was calculated before the implementation of UHI-related policies. Road traffic status data corrected with degree of variability in traffic status, waste heat variables by model and speed in moving targets, and road surface waste heat variables and traffic signal waste heat variables in stationary targets were set as effect variables in effect functions and artificial exhaust heat volume was calculated after the implementation of UHI-related policies.

It should be noted that, as waste heat coefficients by model and speed differ in the daytime (9 am - 8 pm) and the night-time (9 pm - 8 am), artificial exhaust heat volume for moving targets was calculated for both daytime and night-time in addition to calculations for weekdays and holidays, and four types of vehicles in accordance with the categories in the road traffic census. However, as moving target UHI-related policies No.3, 4, 5, 8 and 9 aimed to improve running speed by alleviating and reducing traffic congestion during the day, artificial exhaust heat volume after the implementation of these policies was calculated in the daytime. In addition, as stationary target artificial exhaust heat volume is calculated with one day's worth of waste heat volume, artificial exhaust heat volume after the implementation of stationary target UHI-related policies No. 6 and 7 was calculated by day.

4.2 Results of calculations of artificial exhaust heat volume for moving targets

Using the calculation method shown in the previous section, artificial exhaust heat volume was calculated for both moving and stationary targets. Table 6 shows artificial exhaust heat volume for moving targets which was remarkably

Table 6 Results of Calculation of Artificial Exhaust Heat Volume for Moving Targets by Model
(%, top value: daytime, bottom value: night-time)

Area	Road	Car		Bus		Small truck		Regular truck		Total for each road (10,000 kJ)	
		Weekday	Holiday	Weekday	Holiday	Weekday	Holiday	Weekday	Holiday	Weekday	Holiday
Centre	Metropolitan Expressway No.4 (Shinjuku)	40.0	44.3	3.1	3.2	11.0	11.5	46.0	41.0	18,525.5	19,263.0
		40.0	42.5	3.1	3.1	11.0	11.9	45.9	42.4	17,175.6	18,596.3
	Metropolitan Expressway (ring road)	34.2	33.9	2.2	2.3	8.6	8.6	55.0	55.2	27,567.4	23,664.4
		34.2	33.9	2.2	2.3	8.6	8.7	55.0	55.2	25,553.7	21,929.0
North	Metropolitan Expressway No.5 (Ikebukuro)	30.4	24.1	1.5	1.3	8.1	7.2	60.0	67.3	65,718.4	54,310.9
		29.1	26.2	1.4	1.5	7.7	7.9	61.8	64.5	63,803.3	46,328.1
East	Metropolitan Expressway No.7	42.4	42.4	0.9	0.9	9.5	9.7	47.3	47.0	15,004.4	11,796.6
		42.4	42.5	0.9	0.9	9.5	9.7	47.3	46.9	13,905.7	10,945.2
	Metropolitan Expressway No.9	24.2	23.6	3.7	3.9	7.8	8.0	64.3	64.5	8,692.3	6,431.9
		24.2	23.7	3.7	3.9	7.8	8.0	64.3	64.3	8,057.0	5,965.7
West	Chuo Expressway	44.3	43.2	3.8	4.1	9.9	10.2	42.0	42.5	5,016.0	3,225.7
		44.3	43.3	3.8	4.1	9.9	10.2	42.0	42.4	4,650.6	2,992.6
Northeast	Metropolitan Expressway No.6	23.6	23.1	1.8	1.8	6.9	6.9	67.7	68.3	25,894.5	24,716.8
		23.6	23.1	1.8	1.8	6.9	6.9	67.7	68.2	24,004.1	22,912.8
Southeast	Metropolitan Road No. 482 (Daiba/Ome)	41.3	41.3	3.9	3.9	15.5	15.5	39.3	39.3	43,851.8	43,851.8
		41.3	41.3	3.9	3.9	15.5	15.5	39.3	39.3	40,656.0	40,656.0
	Metropolitan Expressway (coastal route)	17.7	17.2	3.3	3.3	6.5	6.5	72.5	72.3	17,210.4	17,075.9
		17.7	17.4	3.3	3.3	6.5	6.5	72.5	72.3	15,944.7	15,810.1
Southwest	Tokyo-Nagoya Expressway	24.7	25.5	1.2	1.1	4.5	4.4	69.6	68.9	27,915.1	30,333.7
		24.9	25.5	1.2	1.1	4.5	4.5	69.3	68.9	25,907.1	28,105.9
Total for roads in the Tokyo 23-ward area		35.8	35.5	2.4	2.4	12.2	12.4	49.6	49.7	33,374,492.9	31,197,133.8
		35.8	35.5	2.4	2.4	12.2	12.4	49.6	49.7	30,939,244.8	28,921,064.8

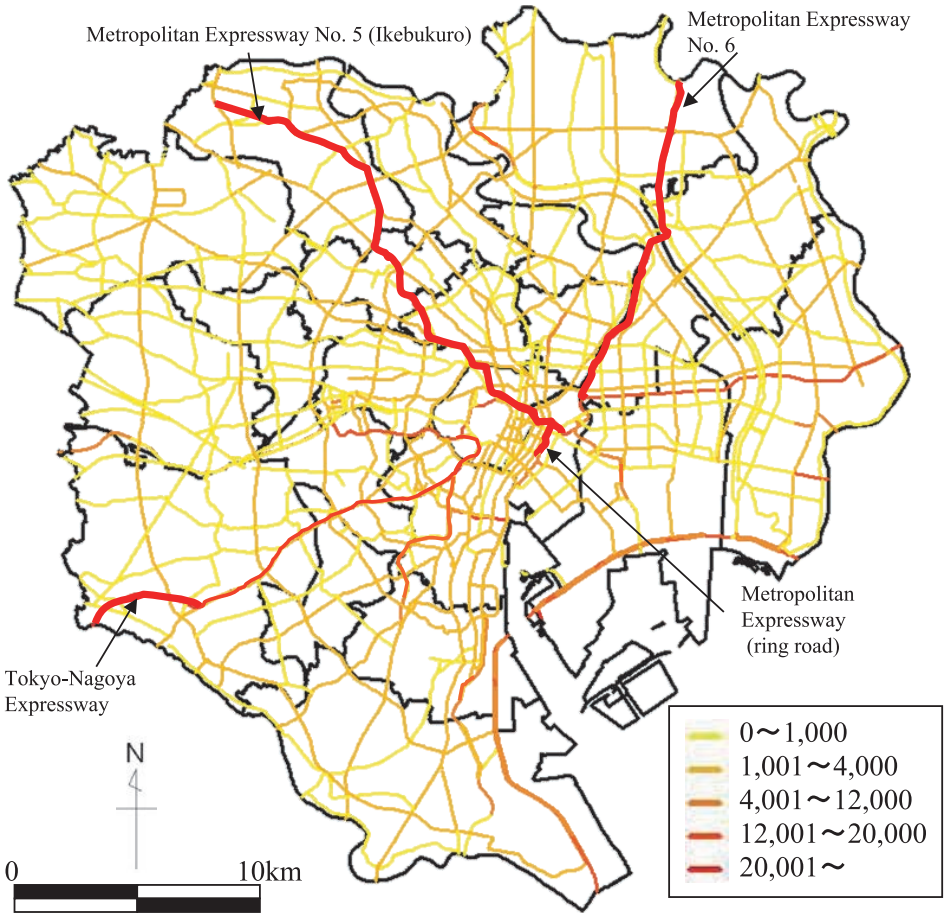

Figure 3 Status of Artificial Exhaust Heat Volume in Daytime on Weekdays (10,000 kJ, total of all vehicles)

high in comparison to that of stationary targets. Figure 3 shows the weekday daytime status where artificial exhaust heat is at its highest. In addition, as artificial exhaust heat volume was high for all vehicles, regardless of the time, on the same roads with remarkable vehicles numbers and running speed such as expressways and ring roads, Table 6 shows artificial exhaust heat volume for all these roads. It should be noted that artificial exhaust heat volume for stationary targets was 1,336,070,000 kJ from road surface and 6,939,200,000 kJ from traffic lights for one day on all roads in the Tokyo 23-Ward Area. Total artificial exhaust heat volume for these stationary targets was not more than around 1.3% of total artificial exhaust heat volume for both daytime and night-time for moving targets on both weekdays and holidays.

The greatest characteristic of vehicles by model was that artificial exhaust heat volume for cars and regular trucks on all roads was high on both weekdays and holidays, during the day and at night. If these values are amalgamated, they account for more than 80% of artificial exhaust

heat volume for each road. Artificial exhaust heat volume was high on weekdays for all roads excluding those in central and south-western areas in the weekday / holiday category, and it was high in the daytime for all roads in the daytime / night-time category. Metropolitan Expressway No.5 (Ikebukuro) in the northern area in particular had higher disparity between daytime and night-time on holidays than other roads.

5. Evaluation of UHI-related policy

5.1 Evaluation of UHI-related policy for moving targets

A comparison was made between artificial exhaust heat volume after the implementation of policies using effect functions in UHI-related policies No.1, 2, 3, 4, 5, 8 and 9 for moving targets, and artificial exhaust heat volume before the implementation of policies using initial functions and related policies were evaluated. Table 7 shows the proportion of reduction of artificial exhaust heat volume after the implementation of UHI-related policy for roads with high artificial exhaust heat volume in the same way as Table 6.

It was understood that, for the Tokyo 23-Ward Area overall, the reduction ratio of No.2 (suppression of waste heat through choice of fuel burned) was high at over 10%, and that it was possible to reduce artificial exhaust heat volume, albeit slightly, in No.3 (improvement of traffic flow by securing space for cyclists and pedestrians), No.4 (development of bypasses), and No.8 (upgrading signal control). In addition, in No.2, apart from Metropolitan Expressway No.5 (Ikebukuro), the reduction ratios on weekdays and holidays were of a similar level, and it can be said that the effect of implementation was higher during the day in particular. However, after the implementation of No.1 (spread of low-emission vehicles), it was suggested that there is

Table 7 Reduction Ratio of Artificial Exhaust Heat Volume After the Implementation of UHI-Related Policies (excluding No.7) (%, top value: daytime, bottom value: night-time)

Area	Road	Moving targets														Stationary targets
		No.1		No.2		No.3		No.4		No.5		No.8		No.9		No.6
		Weekday	Holiday	Weekday	Holiday	Weekday	Holiday	Weekday	Holiday	Weekday	Holiday	Weekday	Holiday	Weekday	Holiday	
Centre	Metropolitan Expressway No.4 (Shinjuku)	0.2	(+6.4)	11.5	5.7	0.0	0.0	0.0	5.6	0.0	0.0	0.0	0.0	0.0	0.0	24.7
		(+7.6)	(+10.2)	5.9	3.7	-	-	-	-	-	-	-	-	-	-	
	Metropolitan Expressway (ring road)	0.2	0.2	11.3	11.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.7
		(+7.6)	(+7.6)	5.6	5.6	-	-	-	-	-	-	-	-	-	-	
North	Metropolitan Expressway No.5 (Ikebukuro)	0.2	12.5	11.1	21.9	0.0	12.3	12.2	12.3	0.0	12.3	0.0	12.3	3.4	12.3	27.7
		(+2.7)	(+2.5)	9.7	9.7	-	-	-	-	-	-	-	-	-	-	
East	Metropolitan Expressway No.7	0.2	0.2	11.8	11.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.7
		(+7.6)	(+7.5)	6.3	6.3	-	-	-	-	-	-	-	-	-	-	
	Metropolitan Expressway No.9	0.2	0.2	10.6	10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.0
		(+7.6)	(+7.5)	4.8	4.8	-	-	-	-	-	-	-	-	-	-	
West	Chuo Expressway	0.2	0.2	11.6	11.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.7
		(+7.6)	(+7.5)	6.1	6.0	-	-	-	-	-	-	-	-	-	-	
Northeast	Metropolitan Expressway No.6	0.2	0.2	10.7	10.7	0.0	0.0	6.4	1.9	0.0	0.0	0.0	0.0	3.4	3.7	27.7
		(+7.6)	(+7.6)	5.0	5.0	-	-	-	-	-	-	-	-	-	-	
Southeast	Metropolitan Road No. 482 (Daiba/Ome)	0.2	0.2	11.5	11.5	4.5	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.7
		(+7.6)	(+7.6)	5.9	5.9	-	-	-	-	-	-	-	-	-	-	
	Metropolitan Expressway (coastal route)	0.2	0.9	10.3	10.8	0.0	0.6	0.0	0.6	0.0	0.6	0.0	0.6	0.0	0.6	27.7
		(+7.7)	(+7.0)	4.4	4.9	-	-	-	-	-	-	-	-	-	-	
Southwest	Tokyo-Nagoya Expressway	0.2	0.2	10.8	10.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.7
		(+7.5)	(+7.6)	5.2	5.1	-	-	-	-	-	-	-	-	-	-	
Total for roads in the Tokyo 23-ward area		0.2	0.2	11.3	11.3	2.9	3.0	5.4	3.2	0.1	0.0	2.8	2.9	0.4	0.3	27.7
		(+7.6)	(+7.6)	5.7	5.7	-	-	-	-	-	-	-	-	-	-	

Note: UHI-related policies No.3, 4, 5, 8 and 9 for moving targets had the aim of improving running speed by alleviating and reducing daytime traffic congestion therefore only daytime artificial exhaust heat volume after the implementation of these policies was calculated, and as values for night-time were not calculated, the relevant cells for night-time reduction ratios are marked with a -.

Table 8 Reduction Ratio of Artificial Exhaust Heat Volume after the Implementation of UHI-Related Policy No.7 (%)

Area	Road	No.7
Centre	Major Regional Road No.302 (Shinjuku/Ryogoku)	30.9
North	Metropolitan Road No.455 (Hongo/Akabane)	30.9
East	Metropolitan Road No.465	30.9
	Metropolitan Road No.474	30.9
West	Major Regional Road No.3 (Setagaya/Machida)	30.9
Northwest	Major Regional Road No.9 (Ichikawa/Yotsugi)	31.5
Southeast	Metropolitan Road No.482 (Daiba/Ome)	30.9
Southwest	Major Regional Road No.426 (Kamiuma/Okusawa)	30.9
Total for roads in the 23 Wards of Tokyo		30.9

potential for an increase in artificial exhaust heat volume mainly at night. As shown in the previous section, this is because waste heat coefficients by model and speed differ between day and night, and values are set to increase according to improvements in running speed.

Meanwhile, it was discovered that roads with high reduction ratios for artificial exhaust heat volume differed for each UHI-related policy. For example, though the above-mentioned No.1, No.5 (improvement of access roads to airports and ports), and No.9 (diffusion of ETC) did not manage to reduce artificial exhaust heat volume much in the Tokyo 23-Ward Area overall, the Metropolitan Expressway No.5 (Ikebukuro) has a reduction ratio of more than 10% during the day on holidays.

5.2 Evaluation of UHI-related policy for stationary targets

In the same way as in the previous section, evaluation of UHI-related policies No.6 and 7 for stationary targets was conducted. Artificial exhaust heat volume reduction ratio for No.6 (special road surfaces) is shown in Table 7 above, and the reduction ratio for roads with high artificial exhaust heat volume among those installed with traffic signals for No.7 (increase in efficiency of energy consumption equipment) is shown in Table 8. Though differences in reduction ratios were observed for each road as shown in Tables 7 and 8, as discrepancies in road width in No.6 and number of traffic signals by unit length in No.7 were reflected, differences occurred.

By implementing these two related policies, it was discovered that it was possible to reduce artificial exhaust heat volume in the Tokyo 23-Ward Area overall by 27.7% and 30.9% respectively, and that it was possible to obtain the same level of effects in all areas. Consequently, as shown in section 4.2, though artificial exhaust heat volume for stationary targets was remarkably lower than that of moving targets, it can be said that reduction ratio was higher than that of moving targets in this related policy. As the two policies mentioned above are implemented in all Tokyo 23-Ward Area, it is expected that artificial exhaust heat volume will reduce over a wide area.

However, as policy No.7 targets roads installed with traffic signals, implementation effects were not obtained on expressways or ring roads with high artificial exhaust heat volume for moving targets as shown in the previous section. In addition, though this study does not target small-scale roads that are not published in the road traffic census, as it is thought to be possible to expect implementation effects for these with policy No.7, it is necessary to develop a more detailed road traffic status database and conduct

evaluation.

6. Conclusion and Future Research

By using GIS as a database development and information analysis tool in this study, it was possible to develop a digital map database that reflects road traffic status, and to calculate artificial exhaust heat volume for road traffic in each road unit. Specific evaluation of UHI-related policies was then conducted, and artificial exhaust heat volume was able to be explained and displayed in an easy-to-understand manner on a digital map with spatial distribution status.

The conclusions of this study can be summarized by the following three points.

(1) Artificial exhaust heat volume for moving targets was remarkably higher than that of stationary targets, and, in particular, artificial exhaust heat volume was high on roads with remarkable numbers of vehicles and running speeds such as expressways and ring roads. Artificial exhaust heat volume was particularly high for cars and regular trucks by model and for weekdays and holidays, and daytime and night-time, artificial exhaust heat volume was mainly high during the day on weekdays.

(2) In UHI-related policy for moving targets, the suppression of waste heat through choice of fuel burned, improvement of traffic flow by securing space for cyclists and pedestrians, development of bypasses and upgrading signal control managed to reduce artificial exhaust heat volume, even though there were differences in degree of reduction. However, roads with high artificial exhaust heat volume reduction ratio differed with each UHI-related policy.

(3) In UHI-related policy for stationary targets, special road surfaces, and the increase in efficiency of energy consumption equipment achieved a reduction ratio of around 30% in artificial exhaust heat volume, more than moving targets as well as making it possible to expect a reduction in artificial exhaust heat volume on a wide scale.

The following five points require research in the future.

(1) By more effectively using the various functions of GIS and obtaining an accurate understanding of the spatial changes in road traffic status, the calculation of even more rational values. In addition, the calculation of artificial exhaust heat volume in each road unit taking reciprocal effects due to spatial positioning into account.

(2) Even more detailed evaluation of areas which have particularly high UHI density in the Tokyo 23-Ward Area.

(3) Development and evaluation of a detailed road traffic status database targeting small-scale roads.

(4) Understanding of the implementation effects of each UHI-related policy and proposals for effective policy implementation plans.

(5) Application of the evaluation methods in this study to other urbans areas with high UHI density and evaluation.

Notes

(1) The GIS used in this study was ESRI's Arc GIS Desktop Arc Info (Ver. 9.2).

(2) Geographical Survey Institute (issued 2003 (6 issues)), numerical map 2500 (National Geospatial Framework) Kanto - 3

(3) Japan Society of Traffic Engineers (2007) 2005 Road Traffic Census National Road / Street Traffic Status Survey

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Editor's Notes

We are sorry for late publication of Volume 8 Number 1 of the Journal of Socio-Informatics. Through the peer review, two of three submitted papers have been accepted as original papers.

From this volume, the translation papers, which were firstly published in the journals of JSIS, JASI, or SSI, will be published. You are welcome to submit original papers and translation papers.

The Editors

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