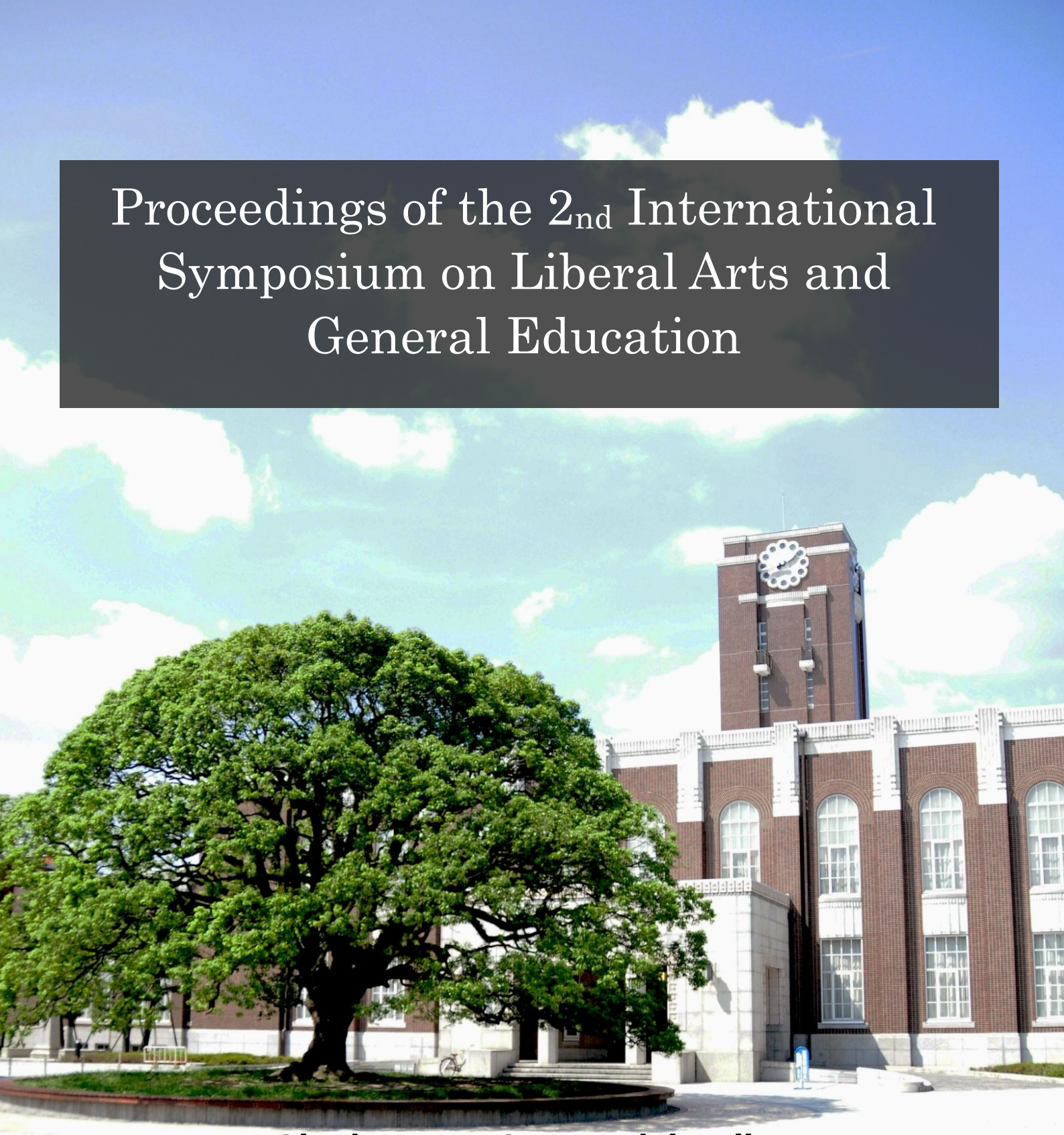
Proceedings of the 2nd International Symposium on Liberal Arts and General Education



Clock Tower Centennial Hall

Kyoto University

November 23, 2011

京都大学
KYOTO UNIVERSITY

Preface

Welcome to the proceedings of the 2nd International Symposium on Liberal Arts and General Education which took place at Clock Tower Centennial Hall in Kyoto University, on November 23, 2011. This was the second International Symposium on Liberal Arts and General Education sponsored by Kyoto University in cooperation with OSAKA GAS CO., LTD and The Scientific Education Exchange.

With more and more high school students being able to pursue their studies in universities, reform and enhancement of higher education have become urgent business since the quality of the graduates need to be guaranteed. Many Japanese institutes of higher education are adopting the American program, and it is often reported that this system works well. As for Kyoto University, we have tried to adopt this program from the last year. We expect that our symposium would motivate the students to learn what they want and also we hope they would become sophisticated and acquire an independent global view through this symposium.

This year, we had 88 paper submissions from undergraduate students who belong to various faculties in various types of research area. Each of the submitted papers was reviewed by graduate students. Finally we accepted 11 papers. In order to motivate students to carry out research works, the following awards are prepared: Outstanding Presentation Award, Suzuran Award and EINSTEIN Award.

At last, we would like to thank our sponsors, corporate partners, and all the members of the Organizing Committee, especially the Symposium Chair, Miki Kioka, the Advisory Committee, Koji Koyamada and Naohisa Sakamoto. Without their invaluable contributions, this event would not have been possible.

Symposium Committee

Contents

Symposium Committee

Symposium Chair

Miki Kioka (Institute for the Promotion of Excellence in Higher Education)

Organizing Chair

Ryo Ioi (Graduate School of Letters)

Program Committee Chair

Katei Kaku (Graduate School of Engineering)

Publicity Co-Chairs

Joe W.Rochenbach (Faculty of Engineering)

Kohei Miwa (Faculty of Engineering)

Kun Zhao (Graduate School of Engineering)

Organizing Committee

Joe W.Rochenbach (Faculty of Engineering)

Katei Kaku (Graduate School of Engineering)

Kohei Miwa (Faculty of Engineering)

Kun Zhao (Graduate School of Engineering)

Saya Kimoto (Graduate School of Human and Environmental Studies)

Secretary

Saya Kimoto (Graduate School of Human and Environmental Studies)

Advisory

Koji Koyamada (Institute for the Promotion of Excellence in Higher Education)

Naohisa Sakamoto (Institute for the Promotion of Excellence in Higher Education)

Reviewer (Graduate School of Kyoto University)

Gen Hayase

Kei Hiruma

Kyoko Hosogoshi

Chih-Wei Hsu

Yusa Ko

Haruka Okui

Hironori Watari

Kimoto Yukinori

Efficient Ways of Memorizing English Words

Akihiro Matsumoto

Faculty of Pharmacy, Kyoto University

Abstract: Today, most Japanese people study English in high school. However, they find studying English difficult because they have to memorize a large number of words in a short amount of time and they cannot memorize those words efficiently. Thus, I distributed a questionnaire and conducted research on the related topic. In this paper, I show that studying English with both visual and auditory methods will help you memorize words. In addition, this paper shows that anyone can apply this study method.

Key Words: listening, seeing, English words, Ebbinghaus

1. Introduction

In the global community, English is becoming increasingly important for communicating with people from different countries. You must speak the language fluently, employing a clear accent and proper pronunciation, and you must choose your vocabulary appropriately. To improve your English skills, you must first memorize as many words in English as possible. In Japan, most people are interested in memorizing English words. According to 'yuru yuru white paper', 100 percent of respondents say that they want to speak English, yet 80 percent of respondents say that they fail to study English.(Source: http://yuruken.org/document01.html) They feel bored because they cannot memorize words easily. They also have to memorize too many words. "Space ALC", an English website, states that you need to know at least 3,000 words to communicate with native speakers of the English language. However, knowing 3,000 words is not sufficient; if you want to use English in a business setting, you need to know about 500 more words. (Source: http://eng.alc.co.jp/newsbiz/hinata/cefr/) Thus, people feel that studying English is difficult; my own research shows that 60 percent of respondents agree with that sentiment. (Figure 1) From these results, I am convinced that efficient methods for memorizing English words would be very useful. To provide one way of memorizing such words, this paper focuses on visual and auditory learning.

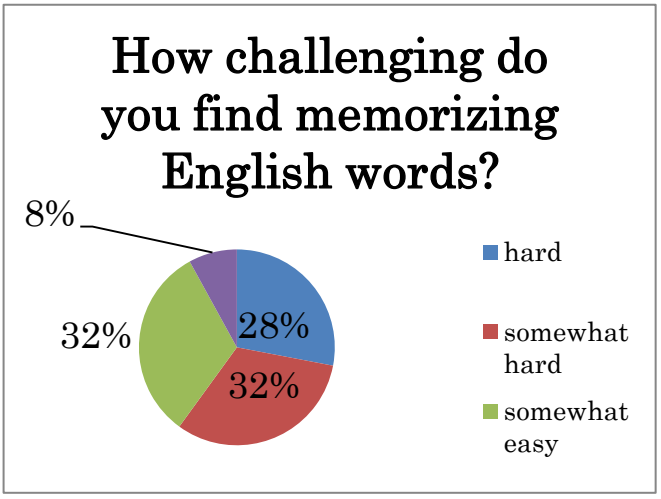


Figure 1: How challenging do you find memorizing English words?

2. Research Procedure

The questionnaire was administered to 25 Kyoto University students. Within the survey, the questions appeared as follows: "When you study English, what do you do?" and "How challenging do you find memorizing English words?"

3. Research Results

From Table 1, you can identify three facts about memorizing English. First, no one memorizes English using only auditory methods. Second, most people study by combining two or more techniques. For example, they study by writing and by listening. Third, those who study visually tend to feel that memorizing English words is very easy.

Table 1: How people study and how challenging they find studying English

	Writing	Seeing	Listening	Pronouncing	Combination
Very difficult	2	2	0	0	4
Somewhat difficult	3	0	0	1	4
Somewhat easy	2	1	0	3	2
Very easy	0	2	0	0	0

4. Hypotheses

From these findings, it appears that visual-based study methods are important in memorizing English words. Seeing words allows you to know the spelling and meaning of words and lets you see those words in the context of example sentences and phrases. Most people memorize English words visually and will agree to this theory. Nonetheless, you can study English even more easily by adding listening techniques.

Matsukawa, Kouda, Muramatsu and Wakayama [4] report that aural information is conducive to learning English. In their research, 351 subjects were asked to memorize 21 words in different ways. Some subjects approached the task of memorization using only words, while others memorized using both words and animation. Then, the results of their test are shown in Figure 2. In the context of these data, the rate of change measures how much the ratio of subjects for whom study was approved changed after the test. At the same time, the intelligibility rate is a measure of the ratio of subjects who understand the content of the study two hours after the experiment. The higher the intelligibility rate is, the more a subject understands the given words.

The results of X1 and X2 are significantly different and indicate that aural information plays a meaningful role in helping you comprehend English. X3 shows that you understand more through sound than you do through English words in multimedia. In brief, by simply listening to English, you can memorize 20 additional words for every 100 words you study, and you can memorize them faster. Another benefit of listening techniques is demonstrated by Ebbinghaus's memory experiment.

Table2: Result of study

Result of study			
Material	Test	Rate of change	Rate of intelligibility rate
X	English→Japanese	48.8	64.2
X1	English→animation	50.6	63.7
X2	Sound→animation	54.2	83.8
X3	English→animation Sound→animation	37.9 60.1	36.7 71.2

Ebbinghaus, a German psychologist, is famous for Ebbinghaus' forgetting curve. In his experiments, he used nonsensical syllables to study how much subjects would remember. (A nonsensical syllable is a word that comprises a consonant, a vowel and another consonant, such as "TOB", "SAB" or "GEX".) Ebbinghaus tried five things to make the condition constant (shown in Table 3) and found that the amount of memory decreased in an exponential manner. In other words, the decreased ratio at the beginning of a period is large, and the decreased ratio after a long time is very small. As shown in Figure 3 (Article source: http://www.field-theory.org/images/memory/forgetting_curve.png), you will not remember anything after two weeks if you do not review the initial memory.

Table 3: Five things to make the condition constant

How to make the condition constant
1. do not change the reading speed
2. regular test
3. study hard
4. study repeatedly
5. lead a constant life

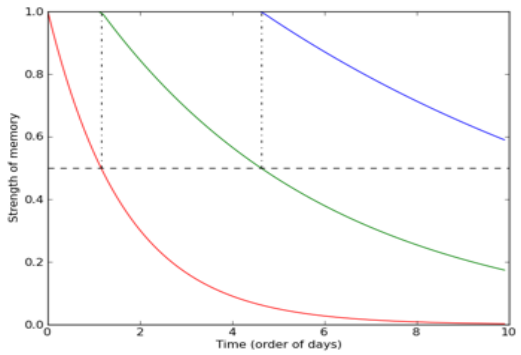


Figure 3: Forgetting curves

How can we retain more English words? The answer is repetition, a hypothesis that can be understood scientifically. Motooka [5] reported that memory was generally divided into two categories: short-term memory and long-term memory. In the context of short-term memory, there are many things that you cannot remember. In addition, you can remember most things for only 15 seconds. On the other hand, regarding long-term memory, you can remember almost anything for an unlimited period of time. To convert short-term memories into long-term memories, you need to utilize repetition. As shown in Figure 5, the more you study English by repeating the words that you learn, the more words you will end up retaining. In addition, if you repeat words soon after the first memorization session, you can improve your ability to memorize them; you simply have to review as much as possible immediately after studying those words for the first time. However, 'yuru yuru white paper' reported that 57 percent of respondents said that they did not to study English because they were busy. For such respondents, no matter how effective a study method is, it will prove useless unless it is easy to use in their daily lives.

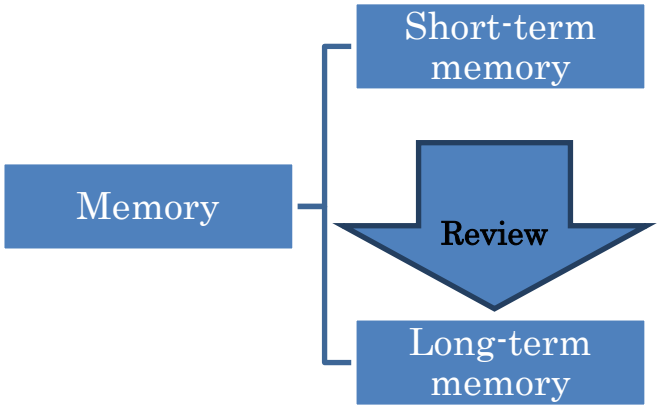


Figure 4: You must review a task to turn short-term memory into long-term memory

Thus, a method that combines both visual and auditory learning is very good for reviewing English words. This method is an easy and simply involves looking at and listening to English words, which allows you to review words anywhere and at any time. For example, you can study when you are commuting; you can examine a textbook and listen to English words out loud as if you were listening to music. I am positive that busy people can also apply this method and enjoy English.

5. Conclusions

Memorizing English words by seeing and hearing them is an effective study method. Without visual learning, you would not be able to know the most important information about the words, such as the correct spelling, usage and grammar. In other words, without seeing the word, you could not even write the word down. Moreover, without auditory learning, you would not understand the correct pronunciation of a word and would not be able to adopt the proper accent. Thus, without hearing the word, you could not converse with people. You also could not memorize words easily and quickly without both seeing and hearing the words. By combining visual and auditory methods, however, you can memorize English words efficiently and, as a result, improve your English skills.

In the research presented here, the experimental scale is not enough to form the basis of a theory. I also did not examine how you should study English visually and auditorily. There may be a difference in efficiency depending on the method (e.g., pronouncing the word you listen to). In my next project, I will research how the efficiency of memorizing English words changes by using visual or auditory methods on a large scale of experimentation.

6. References

[1] Ebinguhausu no kiokuziken to eitanngobocyaburaru ni kan nsuru kousatu [Ebbinghaus's memory experiment and consider ation concerning English word [bokyabiru]] Retrieved from: h ttp://www.geocities.jp/yellowsubmarine0825/Ebbing/Ebbinghaus. html

[2] Kiokuryou wo appusuru houhou [The way of improving your memory] (2008,December) Retrieved from: http://www.nextglobaljungle.com/2008/12/post_373.php

[3] Koritu no yoi oboekataha? [What is the good way of me morizing?] Retrieved from: http://www.edu-cul.co.jp/column/col umn1.html

[4] Matsukawa.R, Kouda.M, Muramatsu.S, Wakayama.K (199 3,August). Eizou.onsei.mozizyouhou no teizihouhou niyoru ga kusyuukouka no chigai nituite [About unlike the learning effe ct according to the method of presenting the image, the voic e, and textual information]

[5] Motoka.N (1996). Goisyutoku ni kansuru bunmyaku no o yobosu yakuwari [The role of context in the acquisition of v ocabulary]

[6] The Ebbinghaus Forgetting Curve – And How To Overco me It Retrieved from: http://sidsavara.com/personal-productivit

y/the-ebbinghaus-curve-of-forgetting
[7] Yoshino.S, Nozima.E, Akahori.S (1997) Eigo no kikitoribamen niokeru zimakufuka no kouka [Effect in effect of title in English catching scene]

A Proposal to Introduce an LRT and Traffic Control Methods in Kyoto City

Akito Kinoshita

Faculty of Engineering, Kyoto University

Abstract: The growing number of tourists in Kyoto causes serious traffic problems, and the issue that has generated the most controversy is the large amount of vehicles entering into the city. To decrease the number of these vehicles and resolve the current situation, the "Kyoto New Face Plan 2022" is proposed. This proposal is composed of five methods: constructing an LRT (Light Rail Transit), the incentive of Park and Ride, enriching the Rental Bicycle service, introducing an integrated billing system and implementing a joint fare system using PiTaPa technology. This plan is designed to encourage visitors entering into the city by cars, who account for 30 % of all visitors, to use public transportation increasingly. This recommendation would not only resolve the traffic problem, but would also create an environmentally friendly city that will attract more people.

Key Words: LRT, park and ride, rental bicycle, integrated billing system, joint fare system.

1. Introduction

Kyoto City is one of the largest tourist cities in Japan and is home to many famous locations, such as Kinkaku-ji Temple, Kiyomizu-dera Temple, and Arashiyama. In 1994, these and other sites in Kyoto were listed on the UNESCO World Heritage Site as the "Historic Monuments of Ancient Kyoto" [1], and in the following years, the number of foreign visitors to the city gradually increased (figure 1). The number of tourists visiting Kyoto in 2010 was 49.55 million, which is thirty-four times as large as the population of Kyoto City [2][3]. Meanwhile, the quality of traffic in Kyoto City has degraded with motorization and the increased number of tourists. Serious and chronic traffic congestions occur throughout the city, especially during the tourist seasons in the spring and fall. Overcrowded roads and buses overfilled with people are visible everywhere in Kyoto during these seasons. Not only are the tourists prevented from smooth sightseeing because of these traffic jams, but people living in the city are also adversely affected in on a daily basis [4]. To resolve this situation, I hereby suggest the "KYOTO NEW FACE PLAN 2022", which proposes introducing the LRT system and other traffic control methods in Kyoto City within ten years. This plan mainly focuses on reducing vehicle use by tourists and adds the new "face" of a state of the art transportation system and technology to the cultural and historical aspects of the city. The word "FACE" stands for FAst, Comfortable and Ecological. The plan is supported by three main principles:

(i) Fast: Achieve smooth traffic by reducing vehicles entering Kyoto for tourism.

(ii) Comfortable: Allow every visitor easy access to famous sites using the combination of the LRT, existing transportation systems, and rental bicycles.

(iii) Ecological: Curb CO2 emission by using the LRT and rental bicycles.

2. Methods

To implement this proposal, information relating to tourism, traffic and transportation in Kyoto City is needed. Therefore, this information is mainly based upon research by the Ministry of Land, Infrastructure, Transport and Tourism, the Kyoto Municipal Government, and the Kyoto Municipal Industry and Tourism Bureau.

3. Results

3.1. The Number of Tourists

According to the statistics from the Kyoto Municipal Industry and Tourism Bureau [2], the number of tourists increased by approximately ten million between 2000 and 2010 (figure 1). This is a good result of the ten-year plan made in 2000, which aimed to attract fifty million tourists in 2010. The number of foreign visitors doubled in ten years to ninety-eight hundred thousand in 2010 [2].

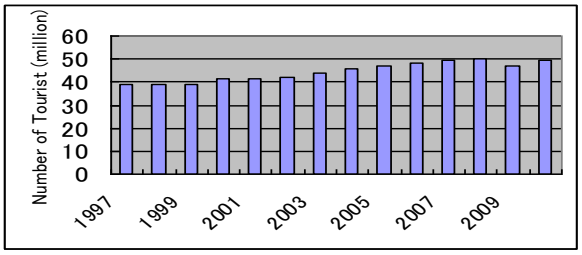


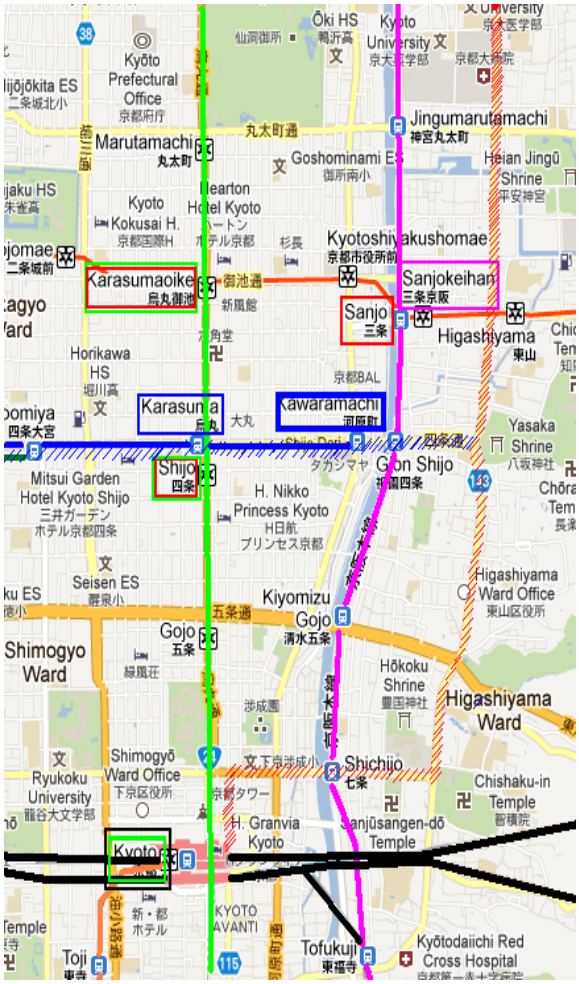
Figure 1: The number of tourists in Kyoto [2].

3.2. Roads in Kyoto City

Fortunately, Kyoto has neither suffered a major earthquake in recent centuries nor was seriously bombed during the Second World War. However, fundamental restructuring of the roads in preparation for motorization was not sufficiently implemented. Furthermore, no expressway runs through the central part of the city. Some of streets were widened in the early 1900s to construct a tram [5].

3.3. Public Transportation in Kyoto City

Several railway companies, such as JR, Hankyu Railway, Keihan Railway, Kyoto Municipal Subway, and Kintetsu Railway, have railway lines running into the center of Kyoto City, but the location of their terminals varies according to the line (map 1). There is no railway directly connecting Shijo-Kawaramachi, Gion-Shijo, Sanjo-Keihan, and JR Kyoto stations.



Map1 by Google Maps: (The red[//////] and blue[//////] lines indicate the planned LRT line. Green: Subway Karasuma-line, Red: Subway Touzai-line, Blue: Hankyu line, Purple: Keihan line, Black: JR and Shinkansen line).

3.4. Bus Service in Kyoto City

Bus services are operated by Kyoto City, Kyoto Bus Company, Keihan Bus Company, and others throughout the city. Almost all tourist locations can be reached with these bus services. However, due to heavy traffic congestion and illegal parking, the operating speed of the bus service is relatively slow, and delay occurs quite often despite the introduction of a bus lane on the main streets in the downtown area. Therefore, Kyoto City and the police began cooperating to impose fines for illegally parked cars by using cameras on the buses to monitor the streets [6] (figure 2).

Figure 2: Red: The roads along the bus routes where the travel speed is less than 20 km/h during rush hour. Blue: The roads which have a bus lane [6].

3.5. Tourism and Transportation

A statistic shows that 28.9 percent of tourists entered Kyoto by car in 2010 (figure 3). Another study shows that most tourists who enter Kyoto by car are not familiar with the directions to their terminus and that they do not reach their destination via the shortest route [7]. These lost cars often use community roads, repeatedly drive the same path and do not choose a proper route [7], all of which further adds to traffic congestion.

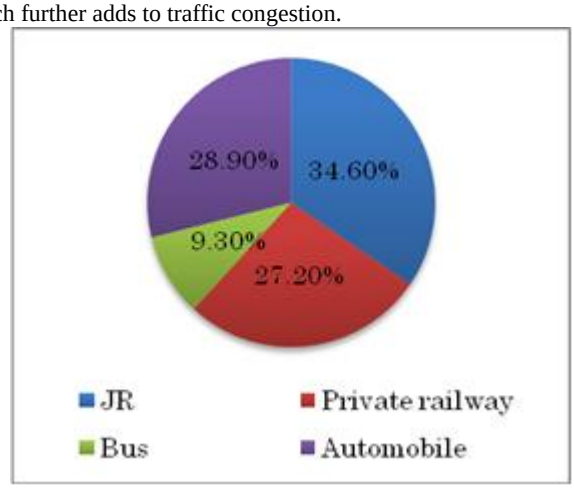


Figure 3: The means of entering Kyoto City by tourists [2].

3.6. Ecology

Kyoto is well known to foreigners not only for its culture and history, but also for the Kyoto Protocol in 1997, which aims to reduce greenhouse gases that cause global warming. Therefore, Kyoto City should become more environmentally progressive. Research shows that automobiles emit CO2 at a rate approximately

five times that of trams (figure 3) [8].

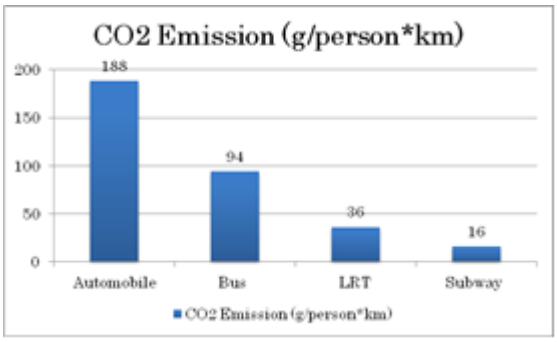


Figure 4: The amount of CO2 emission of vehicles [8].

4. Suggestions

As shown above, the existing traffic system in Kyoto has a significant number of problems. To solve them, I suggest constructing two LRT lines in Higashioji-Street and Shijo-Street.

4.1. About LRT

LRT stands for "Light Rail Transit", and a new type of tram, called the LRV, is used for this system. The LRV differs from the existing tram and bus services in four ways. First, the LRV is a low floor tram that has no stair step between the platform and cabin. Therefore, it is convenient for those who use wheelchairs and the elderly [9]. Second, regular vehicles are restricted from using the railway of the LRT, eliminating traffic jams as a concern [9]. Third, the LRT has strong carrying power. As Table 2 shows, a train of two cars has more than four times the capacity of one regular bus [9]. Thus, the LRT could assist transportation needs during the tourist season. Fourth, the LRT uses a railway system, thus enabling those who do not know the transportation routes to find the LRT easily. Furthermore, a railway could be a strong indicator of designated areas against regular vehicles traffic [9].

Table 2: Carrying Power of Bus and LRT [9]

	Bus - regular	Bus - priority lane	LRT (30m ×1)	LRT (30m ×2)
Vehicle Length	12	12	30	60
capacity	75	75	175	350
Maximum Carrying Capacity (persons/hour, one way)	2500	4000	12000	24000
Average Speed	10~14 km/h	14~18 km/h	15~22 km/h	15~22 km/h

4.2. Route Plan (map 1)

(A) Higashioji-Line

Kyoto Sta. ~ Higashiyama-Nanajo ~ Higashiyama-Gojo ~ Gion ~ Higashiyama-Sanjo ~ Hyakumanben ~ Mototanaka ~ (Eizan Railway) ~ Iwakura ~ Kurama

(B) Shijo-Line

Gion ~ Gion-Shijo ~ Shijo-Kawaramachi ~ Shijo-Karasuma ~ Shijo-Omiya ~ (Keifuku Railway Arashiyama Line) ~ Arashiyama

4.3. Direction

The key goal of this route plan is to direct train services among the Eizan line, Arashiyama line, and two LRT lines. Almost all famous tourist locations and major railway stations can be reached in only one ride (Table 2 [2]). This route plan is not only convenient for visitors, but also integrates and optimizes the flow of traffic. According to the analysis from the Kyoto Municipal Government, business of Higashioji-Line would be profitable in thirty years [15].

Table 3: Most visited sites in Kyoto in 2010 [2] (meshing places are located along the LRT lines)

Ranking	Place	Ratio
1	Kiyomizudera temple	21
2	Arashiyama	16.1
3	Kinkakuji temple	11.3
4	Nijo-castle	9
5	Ginkakuji temple	8.9
6	Nanzenji temple	8.4
7	Yasaka shrine	7.7
8	Kodaiji temple	6.7
9	Heianjingu shrine	6
10	Sagano	5.6
11	Kurama/Kibune	5.4
12	Shijo-Kawaramachi	5.4
13	Ohara	5.3
14	Shimogamo-shrine	5.1
15	Toji-temple	4.9
16	Kyoto Station building	4.6
17	Chion-in shrine	4.6
18	Kyoto Museum	4.6
19	Sanjusangendo temple	4
20	Higashi-honganji temple	3.1

4.4. Supporting Method

To provide incentives to use the LRT and to reduce the use of regular vehicles, the following methods are suggested:

(i) Park and Ride

The Park and Ride service is a system designed to reduce traffic incomes in which people park their cars on the edge of the city and then take public transportation to city center (Oxford Advanced learner's Dictionary, 2005[13]). This service is effective for reducing car usage but could be complemented by the presence of the LRT, which would ensure sufficient means of transit within the city.

(ii) Rental Bicycle Service

To facilitate visitors making short trips inside the

city, the rental bicycle service should be enhanced. Currently, there is the rental bicycle service "Minaport", but it only has five rental stations and 135 bicycles. Compared with the "Velib" in Paris and "Barclay Cycle Hire" in London, this number would be quite insufficient (figure 5) [10][11].

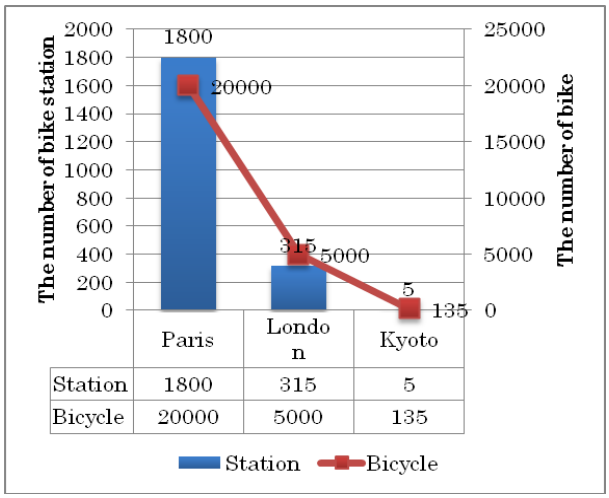


Figure 5: The number of bicycles and their stations in Paris, London, and Kyoto City [10][11][14].

(iii) Integrated Billing System

At present, information technology is used steadily in the billing system. In 2004, the PiTaPa service, which is a contactless IC card ticketing and electronic money system, was introduced. To simplify payment of the LRT, the Ride and Park systems, and the rental bicycle service, PiTaPa technology would be suitable [12].

(iv) Joint Fare System

In the current fare system throughout Japan, passengers must pay the starting fare for every transfer between different transportation companies. A joint fare system would reduce the total fare by removing the transfer fee, and would encourage passengers to use public transportation more efficiently. The PiTaPa service would be helpful in creating the joint fare system, which has been introduced in many European cities [12].

5. Conclusions

Because of the devastating Great East Japan Earthquake and Fukushima nuclear plant disaster, the number of visitors has decreased. However, this situation will recover relatively quickly because Kyoto was not damaged directly and is one of the most popular cities in Japan with its cultural and historical attractions. The purpose of the "Kyoto New Face Plan 2022" is not only to make Kyoto more comfortable and environmentally friendly, but also to raise its renown and the number of tourist visits to the city. Kyoto City and its people should begin to move towards achieving these goals as soon as possible.

6. References

[1] UNESCO World Heritage Convention, Historic Monuments of Ancient Kyoto, available at: http://whc.unesco.org/en/list/688

[2] Kyoto Municipal Industry and Tourism Bureau, Kyoto city tourism annual research report of 2010

[3] Kyoto City, Demographic statistics of Kyoto city: http://www.city.kyoto.jp/sogo/toukei/Population/Estimate/index.html

[4] Kyoto Shinbun Newspaper, "Reportage of autumnal tints and traffic jam in Kyoto" available at: http://www.kyoto-np.co.jp/info/sightseeing/kouyou_zensen/index.html

[5] Teikoku Shinbun Newspaper, "Outline of Three Big Project in Kyoto City", Jun 18th in 1912, available at Kobe University Library Database of Primary sources: http://www.lib.kobe-u.ac.jp/das/jsp/ja/ContentViewM.jsp?METAID=00481961&TYPE=IMAGE_FILE&POS=1

[6] Kyoto Shinbun Newspaper,"Cameras in Kyoto Municipal buses, supply the picture of illegal parking cars to Kyoto prefectural Police" February 18th in 2011, available at: www.kyoto-np.co.jp/politics/article/20110218000159

[7] Kyoto Municipal City Planning Bureau, "Current situation and problem of traffic in Kyoto city" available at: http://www.city.kyoto.jp/tokei/trafficpolicy/tdm/tdm_soan/siryou.pdf

[8] Tsuyoshi M. And Yasuhiro S. "Method of quantitative evaluation using simulation on effect of introducing LRT" National Transfer Safety and Environment Laboratory: http://www.ntsel.go.jp/forum/17files/17-17k.pdf

[9] Yoshitaka A. and Michiyasu K, LRT and sustainable city planning, Section2.

[10] Transport for London, Barclays Cycle Hire http://www.tfl.gov.uk/roadusers/cycling/14808.aspx

[11] Velib "How it works - Stations", http://en.velib.paris.fr/How-it-works/Stations

[12] Yoshitaka A. and Michiyasu K, LRT and sustainable city planning, Section3.4

[13] Oxford Advanced Leaner's Dictionary, Seventh Edition 2005, "Park-and-Ride"

[14] Minaport "Station Map" http://minaport.jp/stationmap/index.html

[15] Kyoto City "The Analysis on New Type of Public Transportation Systems. Available at http://www.city.kyoto.jp/tokei/trafficpolicy/lrt/lrtpdf/lrt-all.pdf

How to Estimate the Influence of Radiation

Akito Mizuno

Faculty of Medicine, Kyoto University

Abstract: On March 11, 2011, an accident occurred at the Fukushima 1 atomic power plant. Subsequently, many people have been concerned about the effects of radiation in their daily lives. However, I noticed that there were two different views on radiation exposure. One view supports the complete avoidance of radiation exposure, while the other states that one can be exposed if it is in low levels. In this essay, I consider the reasons behind these two different views.

Key Words: Low-Dose Radiation, estimation

1. Introduction

The risk estimation of low-dose radiation has become an important issue after the tragic accident that occurred at Fukushima. It is quite clear that high-dose radiation has substantial effects in our lives, and its risk estimation is quite well established. However, as for low-dose radiation, the spectrum of risk estimation varies widely, with two opposite views existing even among scientists.

Scientists use several methods to estimate the risk from exposure to a particular substance. Using one method, they compare the number of people who experience a particular health effect between two groups. The groups are the same except that one group has been exposed to the substance and the other group, known as the "control group," has not. A way of refining the risk estimate is to identify two groups of people who have been exposed to the same substance. One group is made up of people who are experiencing a particular health effect and the other group consists of people who are not. This method allows scientists to identify other risk factors (e.g., family history of the disease) that may make one group more susceptible to the health effect. For example, estimating the risk of cancer in smokers requires a comparison of cancer occurrence between a group of smokers and a group of non-smokers. Both groups would have similar age, education, occupation, and income characteristics, to list a few examples.

Identifying other risk factors (e.g., family history of cancer, level of exercise, and alcohol use) can be achieved by comparing a group of smokers who have cancer with a group of smokers who do not.

We use similar methods to estimate the risks from exposure to ionizing radiation. However, making estimates includes uncertainty because of the following major challenges:

- Developing an exposure history can be extremely difficult.
- Separating the effects from exposure levels that are tens or hundreds of times smaller than exposures due to background is extremely difficult.
- Determining whether radiation exposure is the cause of a particular occurrence of a health effect, such as cancer, is extremely difficult. Many chemicals are also carcinogens.

Then, why is there a difference in the estimation of low-dose radiation? That is because medical professionals and physicists have different concepts. Generally, medical professionals hold the view that one can be safe with low levels of radiation. It may be due to their experience: medical professionals use radiation to cure diseases. On the other hand, physicists take the opposite view, based on the concept of protection. They estimate the risk of radiation conservatively and protectively: they think people should avoid being exposed to radiation and keep the principle of ALARA (”As Low As Reasonably Achievable”) [1].

Shunichi Yamashita, professor at Nagasaki University, who stated, “You can be safe even if you are exposed up to 100 mSv of radiation per year.” [2] In contrast, Toshisou Kosako, professor at the University of Tokyo, stated, “I can’t understand why the government allows elementary school children to be exposed to 20 mSv of radiation per year. 20 mSv is very high.” [3]

In high dose regions, the risk depends almost linearly on the radiation dose, which has been well established. In contrast, in low dose regions, we do not have enough data to establish its dependence, which leads to differences in estimation. (Figure 1)

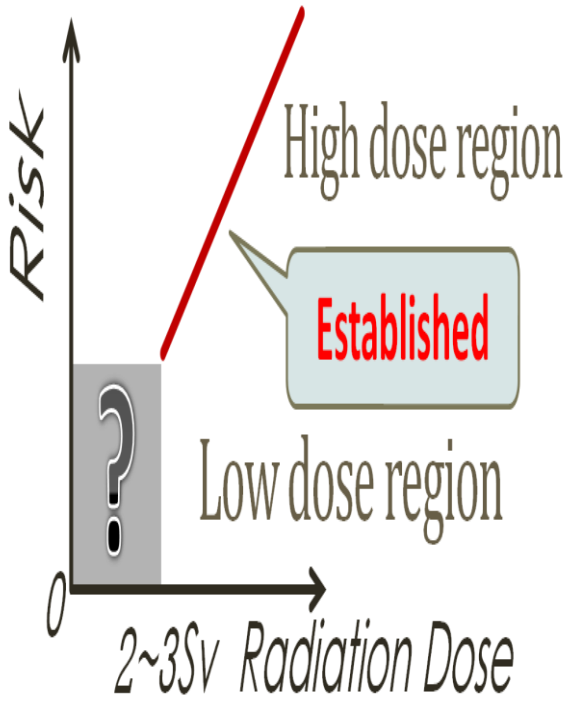


Figure 1: The relationship between risk and radiation dose

The simplest way to estimate risk is to extrapolate the proportional relationship to low dose regions. This is called the LNT (Linear No Threshold) hypothesis, which is the conventional way of estimation. (Figure 2) ICRP (International Commission on Radiation Protection) has adopted this LNT model to develop its protection principle, namely, to make a standard regarding radiation dosage[4].

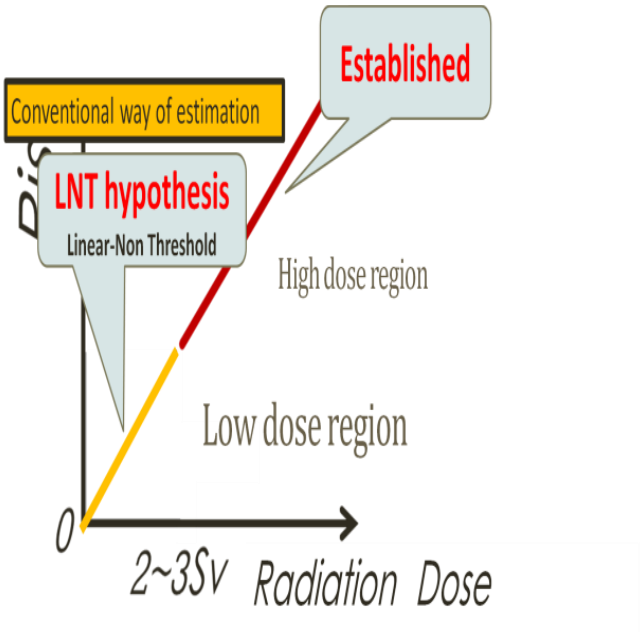


Figure 2: LNT hypothesis model [4]

However, there are various ways of estimating the risk of low-dose radiation. Let me show some typical examples of the data. There is a low-risk model and a high-risk model. (Figure 3) An example of a low-risk model is the hormesis effect model. In the hormesis effect model, a high dose of radiation is toxic, while a low dose of radiation has a good influence on us physiologically. [5] In contrast, an example of a high-risk model is the bystander effect model. In the bystander effect model, the influence of low-dose radiation is estimated to be higher than in the LNT model. This is because radiation influences not only those cells directly exposed to radiation but the adjacent cells as well. [6] There are other examples, such as the petcau effect model, the binomial effect model, the two-phase model, the instability of genome model, the cocktail effect model, the LQ model, and so on [7] [8] [9].

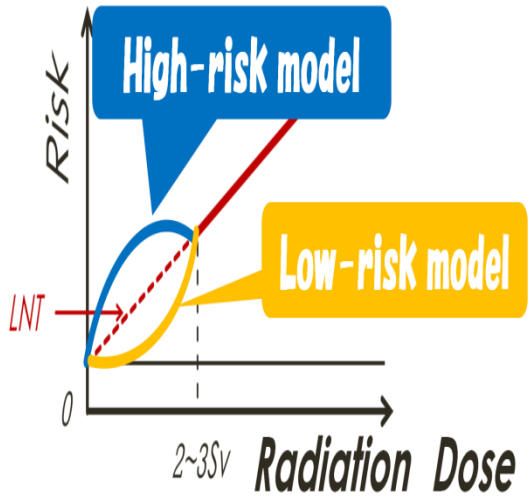
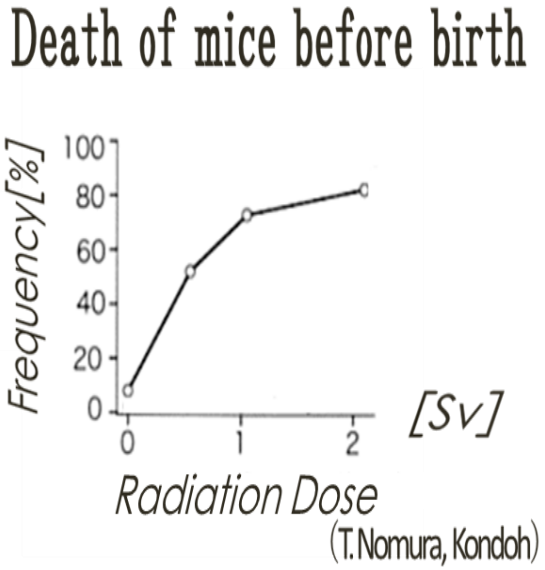


Figure 3: Low-risk model and high-risk model

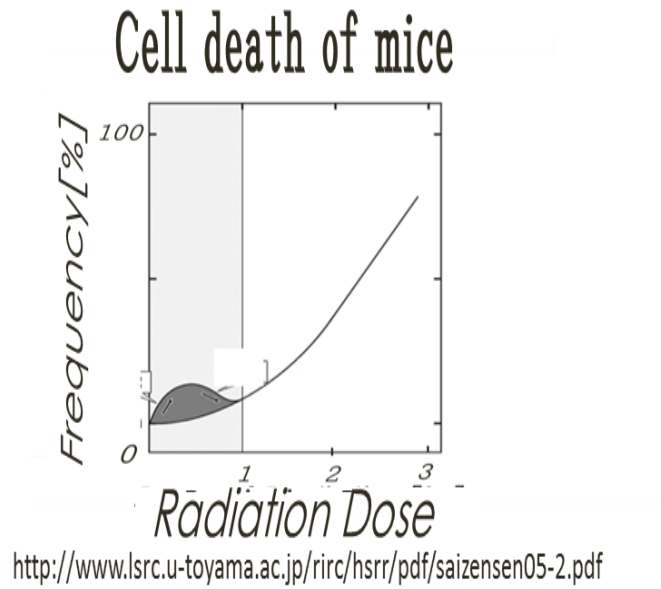
2. Methods and Materials

Radiation damages DNA strands directly and indirectly. If cells are exposed to low LET radiation (e.g., β-ray, γ-ray and X-ray), a free radical is produced, which damages DNA strands indirectly [10]. In contrast, if a cell is exposed to high LET radiation (e.g., α-ray, neutron-ray, baryon-ray, and proton-ray), radiation damages DNA strands directly [10]. However, high LET radiation has a limited ability to penetrate, so we have to consider the influence of low LET radiation only [11]. If DNA strands are damaged, this may lead to three outcomes: (a) damage repair, (b) the death of abnormal cells or (c) a lack of damage repaired (i.e., survival of abnormal cells).

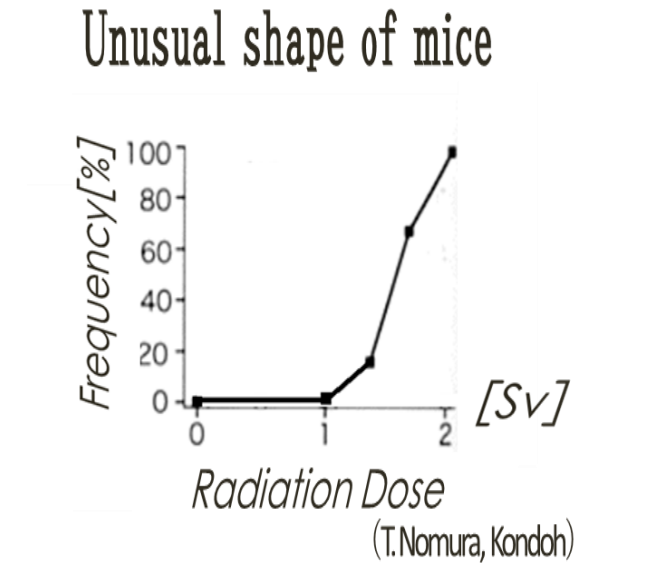
Figure 4 (a) ~ (d) show the relationship between the radiation dose and the frequency of the death of mice before birth, cell death in mice, unusual shapes of mice and white blood cell tumors. I use these data and consider low-dose radiation as high-risk or low-risk.



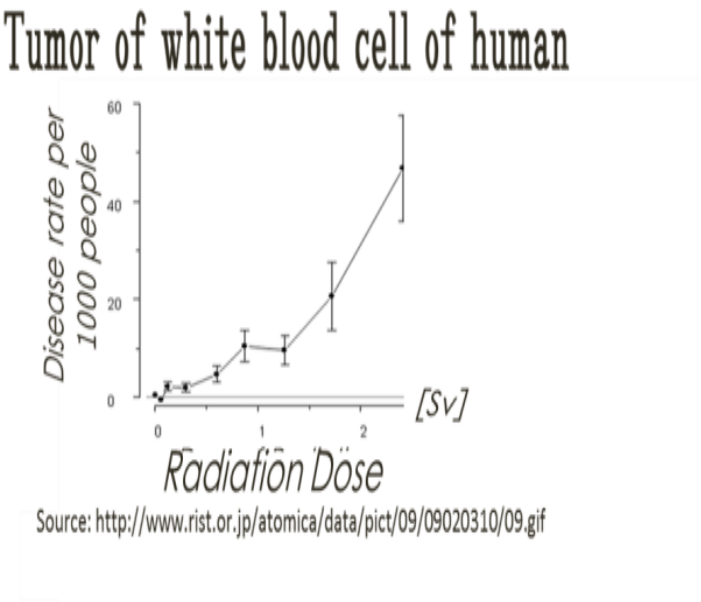
(a) The relationship between frequency of death before birth and the radiation dose



(b) The relationship between frequency of cell death in mice and the radiation dose [12]



(c) The relationship between frequency of unusual shape of mice and the radiation dose



(d) The relationship between human white blood cell tumors per 1000 people and the radiation dose [13]

Figure 4: the relationship between the radiation dose and the frequency of the death of mice before birth, cell death in mice, unusual shapes of mice and white blood cell tumors

3. Results

Figures 4(a) and 4(b) show the high-risk model, while figures 4(c) and 4(d) show the low-risk model. Moreover, in figures 4(a) and 4(b), both death in mice before birth and cell death in mice show the 'death of abnormal cells'. In figures 4(c) and 4(d), both unusual shape of mice and human white blood cell tumors show the 'survival of abnormal cells'.

4. Conclusions

Figures 4(a) to (d) indicate that there is evidence of both high-risk and low-risk models at play. Figures 4(a) and 4(b) show the high-risk model and 'death of abnormal cells'. Although, intuitively, cell death does not seem good for our bodies, if abnormal cells remain, they may cause cancer and have bad effects in the future. Thus, the 'death of abnormal cells' is frequent and beneficial. On the other hand, Figures 4(c) and 4(d) show the low-risk model and the 'survival of abnormal cells'. The survival of abnormal cells is a risk to our bodies, although the risk itself is low.

In conclusion, there is evidence supporting both high–risk and low-risk models. However, the death of abnormal cells is frequent and beneficial, while the survival of abnormal cells is risky, albeit at a low level.

Based on such considerations, low-dose radiation can be considered safe.

5. Future Direction

Low dose of radiation may be safer than many of us previously thought. However, the level of data is too limited to definitively confirm this. Therefore, more data are needed to confirm whether

low-dose radiation is safe.

6. Acknowledgements

I'm grateful to the members of the low-dose meeting, Ms. Bando, Ms. Uno, Mr. Matsuda, Ms. Takehama, Mr. Manabe, Ms. Hirota, Mr. Itoh H, Mr. Itoh M, Ms. Sugino, and Mr. Maura, for helping me write this essay.

7. References

[1]http://ssu.mri.co.jp/columns/articles/vol058
[2]http://ja.wikipedia.org/wiki/%E5%B1%B1%E4%B8%8B%E4%BF%8A%E4%B8%80
[3]http://www9.nhk.or.jp/kabun-blog/200/80519.html
[4]http://criepi.denken.or.jp/jp/ldrc/study/topics/lnt.htm
[5]http://ja.wikipedia.org/wiki/%E3%83%9B%E3%83%AB%E3%83%9F%E3%82%B7%E3%82%B9%E5%8A%B9%E6%9E%9C
[6]http://www.life-bio.or.jp/topics/topics417.html
[7]http://www.rri.kyoto-u.ac.jp/NSRG/kouen/mss081122.pdf
[8]http://www.rist.or.jp/atomica/data/dat_detail.php?Title_No=09-02-02-09
[9] http://sakitani.net/html/news19.html
[10]飯田博美，「放射線概論」，通商産業研究社，2001, p243,244,250,255,259,276,283
[11]http://www.kagakudojin.co.jp/files/c27012-08.pdf
[12]松本英樹：北陸地域アイソトープ研究会誌，第7号, 2005, p36. Available at http://www.lsrc.u-toyama.ac.jp/rirc/hsrr/pdf/saizensen05-2.pdf
[13]Preston DL, Pierce DA, Shimizu Y, Cullings HM, Fujita S, Funamoto S, Kodama K: Effect of recent changes in atomic bomb survivor dosimetry on cancer mortality risk estimates, Radiation Research, 162, 377-389, 2004. Available at http://www.rist.or.jp/atomica/data/pict/09/09020310/09.gif

Further Development of Japan's Democracy in the Judiciary through Citizen Participation in Civil Trials

Maki Nakata

Faculty of Law, Kyoto University

Abstract: The saiban-in system is currently used only in serious criminal cases in Japan. However, its use in civil cases could benefit the Japanese judicial system by providing more convincing and less irrational verdicts. In this article, the pros and cons of the American jury system are investigated as a reference point for our citizen participation system in Japan. The citizen participation system offers several advantages, as it better reflects public opinion and includes a wider range of viewpoints to provide more coherent factual findings. However, the introduction of the saiban-in system into civil trials would require diligent preparation by judges before each trial and necessitate a reconsideration if the linkage between the lower and appellate courts. This article concludes that the introduction of the saiban-in system into civil trials is worth consideration and could further develop a democratic judiciary in Japan.

Key Words: citizen-participation system, civil case, democracy, determination of facts

1. Introduction

The "saiban-in" system ("citizen judge" or "lay judge" system in a loose translation) was introduced in serious criminal cases in Japan in 2009 and is expected to facilitate citizens' understandings of criminal cases and reflect their opinions in verdicts. It is noteworthy that citizen judges generally approve of the current saiban-in system. One questionnaire reveals that as many as 95.2% of those who served as lay judges say they are satisfied with their experiences at the court (The Supreme Court, 2011 [17]). In addition, 66.6% of Japanese survey respondents think that public opinion is better reflected in saiban-in verdicts than in the pre-saiban-in system (The Supreme Court, 2011 [18]). These data clearly indicate that the Japanese citizen judge system has positively affected criminal cases. The system could therefore be beneficial in civil cases as well.

The purpose of this paper is to highlight the importance of introducing the saiban-in system into civil trials by focusing on two foreseeable benefits: 1) the production of more convincing verdicts that reflect public opinions and 2) the minimization of irrational verdicts through the inclusion of diverse perspectives when determining facts during the deliberation process.

The views of lay judges may have resulted in different verdicts in several recent civil cases. For example, in one case, a fifth-grade boy kicked a ball into the street, and a court ordered his parents to pay ¥15,000,000 in compensation to the bereaved family of an 87-year-old motorcyclist who tried to avoid the ball but fell and broke his leg. The man later suffered senile dementia and died a little more than a year later from aspiration pneumonia (Asahi Shimbun, 2011, [23]). The stray ball resulted from the boy practicing soccerfree-kicks, and the ball happened to go high and over the goal posts. The judge's verdict was that the boy could have predicted that the ball would go into the street and cause the accident, and the judge accepted the plaintiff's argument that the dead man's life was radically changed by the accident (Yomiuri Shimbun, 2011 [22]).

Several issues make this case contentious. First, the court identified a rational relationship between the accident and the man's demise. Second, the boy was held fully responsible for the accident, and no responsibility was attributed to his school or to the elderly man. From a subjective standpoint, this finding is flawed because the boy is said to be responsible even for the events that occurred after the man had dementia. In addition, the school that positioned the goal post should have some accountability, and one could argue that the man was too old to ride a motorcycle, and he or his family should have foreseen the possibility of an accident. The street also had a "drive slow" sign posted in warning.

An optimistic point of view is that this district court ruling could be reversed by higher courts. However, this case has cost a considerable amount of time and placed a psychological burden on both parties. The introduction of the saiban-in system into civil cases such as this could lead to judgments that reflect citizen's common sense and further promote democracy in the Japanese judiciary.

In discussing the expansion of the current saiban-in system into civil cases in Japan, it is helpful to review the jury system in the United States (US). Although Japan's saiban-in system for criminal cases is closer to the lay judge system than the American jury system is, the latter is significant because the United States attaches a great deal of importance to citizen-participation in judicial decisions. In the remainder of this paper, I will briefly explain the two types of citizen-participation systems and illustrate the advantages of the American jury system, particularly in relation to community representativeness and the influence of citizens' multiple views upon factual findings. Next, I will discuss the disadvantages of the American jury system and suggest possible improvements that can be made to the current saiban-in system. I conclude that, although the benefits of a citizen-participation system are great enough that its introduction in civil trials is worth considering, this investigation points to some necessary cautions.

2. Methods

2.1 The US Jury System as a Case Study

As mentioned, the saiban-in system is closer to the lay judge system than the jury system. In the jury system, lay citizens lead the deliberation process and determine verdicts, with a judge playing a direct role only by giving instructions and a charge to a jury before deliberation (Maruyama, 2007 [14]). In the lay judge system, on the other hand, a group of judges and citizens make decisions together (The Supreme Court, 2011 [19]). This paper examines the US jury system because the citizen-participation model, whether in criminal or civil trials, has been a significant part of that nation's judicial system since its establishment.

In the beginning of the 16th century, the common law was introduced in the United Kingdom (UK); one of the law's clauses states the right of access to the court. When the UK colonized North America, juries played an important role in protecting the rights of the American people from the tyranny of the imperial power. After independence, the US constitution and first ten amendments focused on the guarantee of basic citizen rights. Three of ten amendments pertained to the jury system (Ikeda, 1991 [8]). Consequently, the jury is a central aspect of citizen-participation in the judicial system in the US. The jury system aims to ensure the people's rights to be a part of the country's judicial structure and is therefore of central importance in a democracy.

2.2 Some Distinctive Features of the Civil Jury System in the US

Some distinctive features of the American jury system should be examined in any discussion exploring the ideal style of the saiban-in system. For example, some critics have highlighted the extremely high punitive damages (an outrageous amount of compensation as a deterrent against similar acts in the future) that emerge in the US (Maruyama, 2007 [15]).

The American civil jury could be briefly described as follows. When the amount in dispute is above $5,000, a civil jury is offered both in the US district court and a court of first instance in individual states (except Louisiana). Plaintiffs have the right to demand a jury trial (Cornell University Law School, 2011 [3]). This right can be withdrawn when the other party or its attorneys file a stipulation for a nonjury trial or a court finds that there is no federal right to a jury trial (Cornell University Law School, 2011 [4]).

Jury trials include a variety of types of cases, such as personal injury, medical malpractice, product liability, breach of contract, libel suit, and divorce cases. Most cases address incidents of illegal actions or claims for damages for injuries and infringement on lives (Ikeda, 1991 [9]). Jurors are obligated to decide which side wins and determine claimable amounts. In order for jurors to understand the judgment of a case, judges give instructions about how laws should be applied to the case before deliberation. This is a critical role for judges (Cohen, 1994 [1]). Jurors have the right to ignore the instructions and make a decision deviating from the intentions of the judge (jury nullification). H owever, this rarely occurs because judges have the right to remove such jurors. Judges can also give their own sentences if the juries' decisions are determined to be indefensible (JNOV, or judgment non obstante verdict). A jury's verdict can be further discussed by an appellate court. The court normally does not question a jury's determination of facts but checks whether there have been any mistakes or irrational judgments in deliberations (Cohen, 1994 [2]).

3. Results

3.1 Benefits of the Civil Jury in the US

First, a jury introduces the fresh perspectives and values of ordinary people. Lay citizens may be more convinced by the common-sense decisions made by their community's representatives than by the occasionally abstract decisions made by judges. In addition, it can be beneficial for citizens to have open discussions evaluating experts' legal advice. It has been noted that arguments evaluating experts' testimony are rarer in Japan than in the United States (Yamaguchi, 2003 [20]). Experts develop a variety of opinions and conclusions by analyzing and extrapolating data differently, and neutral evaluations of their testimonies made by citizens should benefit the judgment process.

Second, jurors not only embody democracy in the judicial system, they also fortify arguments in deliberations. Jurors can counter judges' arbitrariness and the prejudices that stem from their long experience. One study suggests that jurors excel at remembering and correcting the misrecognition of facts when compared to a single judge (Ellsworth, 1989 [5]). Because jurors are often participating in a trial for the first time, they pay attention and closely listen to testimony to construct factual findings. On the other hand, judges who go through this procedure routinely may subconsciously apply familiar patterns to the case and sometimes overlook facts that may be significant to their findings (Maruta, 1990 [13]).

In addition, some evidence counters the general concern that jurors may be biased and susceptible to attorneys' speeches. Jurors are said to feel sympathy for plaintiffs, and therefore the winning rate of plaintiffs is presumed to be higher in jury trials than in trials with judges alone. However, data collected in 1996 point to the opposite conclusion. These data come from 15,683 civil trials in 75 regions; most of these trials related to illegal actions, contract lawsuits, and real estate actions (see tables 1 and 2).

Table 1: Percentage of different types of civil trials in 75 regions in 1996

Types of trials	%
Illegal Actions Lawsuits	65.7
- Car accident	31.9
- Installation	14.3
- Medical error	7.7
- Product liability	2.7
- Intentional illegal action	3.1
- Malpractice by professionals	1.2
- Libel	0.7
- Other negligence	4.1
Contract Lawsuits	31.0
Real Estate Lawsuits	3.3

(Source: Sato, Tatsufumi. Beikoku ni okeru Minji Baishin Saiban ― Saibankan ni yoru Saiban to Hikaku shite [The Civil jury Trials in the

United States; with Comparison to the trials by judges]. *Hanrei Times.* No. 1039 (2000): 14.)

Table 2: Ratio between ordinary and jury trials in each type of trials

Types of trials	Jury trials (%)	Judge trials (%)
Illegal Actions Lawsuits	85	15
Contract Lawsuits	36	64
Real Estate Lawsuits	21	79
Overall	68	32

(Source: Sato, Tatsufumi. Beikoku ni okeru Minji Baishin Saiban ― Saibankan ni yoru Saiban to Hikaku shite [The Civil jury Trials in the United States; with Comparison to the trials by judges]. *Hanrei Times.* No. 1039 (2000): 14.)

It is noteworthy that the winning rate of plaintiffs in the overall civil jury trials is 48.7%, whereas their winning rate in trials with judges alone is 61.6%. In illegal actions lawsuits, the winning rate of plaintiffs in jury trials is 47.5%, while their winning rate in trials with judges is as much as 56.9% (See table 3) (Sato, 2000 [16]).

Table 3: The winning rates of plaintiffs in jury and judge trials

	The winning rates of plaintiffs (%)		
	Jury trials	Judge trials	Overall
Illegal Action Lawsuits	47.5	56.9	48.2
Contract Lawsuits	55.6	67.8	62.4
Real Estate Lawsuits	35.7	30.5	31.8
Overall	61.6	48.7	52.0

(Source: Sato, Tatsufumi. Beikoku ni okeru Minji Baishin Saiban ― Saibankan ni yoru Saiban to Hikaku shite [The Civil jury Trials in the United States; with Comparison to the trials by judges]. *Hanrei Times.* No. 1039 (2000): 15.)

Other studies have also demonstrated that the susceptibility of jurors to lawyers' speeches is insignificant. One study compared the decisions of jury trials and presumable decisions by judges on the same cases and concluded that the differences in decisions due to the abilities of attorneys were as little as 0.25% (Kalven, 1966 [10]).

3.2 Costs of Civil Juries in the US

Some of the criticisms of the civil jury system in the US should be considered in discussions about the introduction of a civil saiban-in system in Japan. Two particular issues are the focus of this section.

First, some experts question whether jurors are able to understand judicial rules sufficiently to apply them to actual facts. One study revealed that even though jurors understand what kind of bills should be applied to specific cases (Loh, 1983 [12]), they do not perfectly understand judge's instructions in most cases (Hans, 1989 [7]). However, judges rather than jurors are to blame for this misunderstanding (Elwork, 1982 [6]). Though juries make enough sense of what is going on to deliberate rationally and can usually reach defensible verdicts, they also make identifiable mistakes. These mistakes are linked to systematic deficiencies in trial processes and to hard-to-understand jury instructions (Lempert, 1993 [11]).

Second, unlike in criminal cases, the efforts of juries can be sometimes wasted in civil cases if plaintiffs and defendants eventually come to settlements during deliberations. For example, one complicated case in California took 21 months to deliberate and ended in a settlement when the verdict was about to be discussed (Ikeda, 1992 [9]). This case suggests that the court should cautiously determine whether there is a possibility of settlement in the future and concretely identify the issues that should be discussed by the jury.

4. Discussion

In the civil-participation system, a wide range of standpoints are used to determine facts, especially cause-and-effect relationships based on scientific evidence. If the incident of the soccer-playing boy had been discussed with jurors, the validity of the judges' argument that the boy could predict that the ball would go in the street and cause an accident could have been amply discussed from a variety of viewpoints. In addition, jurors could appraise the legitimacy of the causal link made between the old man's death and the motorcycle incident (particularly whether the man's broken leg could cause senile dementia). A jury discussion could have also determined whether the boy alone should be responsible for the whole accident and what portion, if any, of the man's condition the boy should be held responsible for.

However, there are three limitations that should be kept in mind regarding the data discussed in this article. First, the comparison of plaintiff winning rates does not necessarily conclusively show that jurors always give harsher verdicts to plaintiffs than judges. Because individual states in the US have different trial systems, their results are not easily comparable.

Second, the fact that jurors are better at pointing out facts than a judge results from a comparison of a group of jurors with a single judge. In the saiban-in system, there are three professional judges, and it is possible that the group of judges will be inferior or superior to the group of laymen. However, it is still compelling to note that a jury can counter a judge's arbitrariness and the prejudices that stem from their long experience.

Third, data that show the insignificance of jurors' susceptibility to attorneys' speeches also indicate that jurors are likely to be influenced by the abilities of attorneys in one in 400 cases. However, unlike the US, Japan uses a lay judge system that includes judges. Judges should confirm only facts that are pertinent to the deliberation to avoid the influence of rhetorical techniques. All in all, given the juries' determination of facts and the susceptibility of either party to prejudice, the problems of juries can be controlled with the subjective standpoints of judges.

The American civil jury system also has some benefits that should be applied to the saiban-in system in civil trials. In the US, some cases go to appellate courts where judges discuss their validity based on the decisions made by juries. Therefore, unless there are obvious mistakes and errors in the deliberation process or the verdict itself, judges at the appellate court take into account the

opinions of jurors at the lower court. Japan, on the contrary, does not have any stipulation of respect for lower court decisions. If the juries' decisions are to be easily overturned and their perspectives discarded, the ultimate purpose of civil participation is ruined. However, one survey revealed that lay judges do not mind the appellate court's ability to ignore their opinions. According to a survey of people who served as lay judges, only 16% of them answered that the decisions made in a lower court should be respected in an appellate court, while as much as 81% of the people think judges should give their own decisions if necessary (Yomiuri shimbun, 2011 [21]). This percentage indicates that the Japanese respect judges' decisions more than those of citizens. However, it also means that citizens think highly of judges as professionals and expect them to check the decisions juries make. Therefore, as long as the judges at an appellate court do not find any irrationality in the decisions of juries, the appellate court should respect what had been discussed in a lower court, not replace juries' decisions and begin a new deliberation.

In addition, there are two things that judges should be aware of to improve the quality of trials. First, judges should determine whether the cases need to be judged by juries to avoid arrangements between parties in the middle of deliberations. Second, judges' instructions for cases should be clear so that all jurors can fully understand and discuss the matter. Unclear instructions make the deliberation process in the US more complex. Judges should narrow down the points to be discussed and clearly identify what should be concluded.

All things considered, it has been demonstrated that citizen participation in civil trials ensures satisfying verdicts by bringing in the opinions of lay citizens and minimizing irrationality through a more refined process of determining facts. Suggested measures for improving citizen participation are attainable, and the significance of introducing a citizen judge system into civil cases is evident.

5. Conclusions

The introduction of the saiban-in system into civil cases would benefit people and trials. If judges better clarify the deliberation process for lay judges and appellate courts are required to pay more respect to citizens' verdicts, citizen-participation and a more democratic process in the Japanese judicial system can be further enhanced through the introduction of the saiban-in system to civil litigations.

6. References

[1][2] Cohen, Jay. Beikoku Minji Baishin Seido ni tsuite [About the Civil Jury Trials in the United States]. *Kokusai Shouji Houmu 2*. No.2 (1994). 110-116.

[3] Cornell University Law School. *Federal Rules of Civil Procedure. Rule 38.* http://www.law.cornell.edu/rules/frcp/Rule38.htm (September 27, 2011).

[4] Cornell University Law School. *Federal Rules of Civil Procedure. Rule 39.* http://www.law.cornell.edu/rules/frcp/Rule39.htm (September 27, 2011).

[5] Ellsworth, Phoebe. Are Twelve Heads Better Than One?. *Law And Contemporary Problems 52,* No.4 (1989): 205-224.

[6] Elwork, Anthony et al.. Making Jury Instructions Understandable (1982).

[7] Hans, Valerie P.. The Jury's Response to Business and Corporate Wrongdoing. *Law & Contemporary Problems 52* (1989).

[8] Ikeda, Shigeho. Beikoku oyobi Eikoku no Baishin Seido wo Megutte (1) [About the Jury system in the United States and the United Kingdom (1)]. *Hou no Shihai* No. 88 (1991): 131-157.

[9] Ikeda, Shigeho. Beikoku oyobi Eikoku no Baishin Seido wo Megutte (2) [About the Jury system in the United States and the United Kingdom (2)]. *Hou no Shihai* No. 89 (1992): 75-94.

[10] Kalven, Harry & Zeisel, Hans. The American Jury 33-54 (1966).

[11] Lempert, Richard. Civil Juries and Complex Cases: Taking Stock After Twelve Years. *Verdict: Assessing the Civil Jury System* 181(1993): 181-247

[12] Loh, Wallace. Social Research in the Judicial Process 430 (1984); Hastie, Reid et al. Inside the Jury (1983).

[13] Maruta, Takashi. Minji Baishin wo meguru Shinwa to Genjitsu; Naze Minji Baishin Seido ga Hitsuyou ka [The Myth and the Reality of the Civil Jury; Why Do We Need the Civil Jury System]. *America Hou* No. 1990-2 (1990):169-231.

[14][15] Maruyama, Toru. *Nyumon; America no Shihou Seido ― Baishin Saiban no Rikai no tameni [An Introduction to the American Judicial System; for Understanding the Jury Trials]*. Tokyo: Gendai Jinbunsha, 2007

[16] Sato, Tatsufumi. Beikoku ni okeru Minji Baishin Saiban ― Saibankan ni yoru Saiban to Hikaku shite [The Civil jury Trials in the United States; with Comparison to the trials by judges]. *Hanrei Times.* No. 1039 (2000): 14-17.

[17] The Supreme Court. *Saiban-in Seido no Jisshi nit suite No.1 [About an Implementation of the Saiban-in System No.1].* http://www.saibanin.courts.go.jp/topics/h21_saibanin_kekka.html (Accessed September 21, 2011)

[18] The Supreme Court. *Saiban-in Seido no Jisshi nit suite No.2 [About an Implementation of the Saiban-in System No.2].* http://www.saibanin.courts.go.jp/topics/h21_saibanin_kekka.html (Accessed September 21, 2011)

[19] The Supreme Court. *Saiban-in Seido Q&A; Baisin-sei ya Sanshin-sei toha Chigau no desuka?[The Saiban-in System Q&A; Is it Different from the Jury and the Lay Judge System?].* http://www.saibanin.courts.go.jp/qa/c8_2.html (Accessed September 25, 2011)

[20] Yamaguchi, Tatsuyuki. Minji Sosho ni okeru Kagaku Kantei ni Kansuru Ichi Kousatsu [A Discussion about Scientific Testimonies in Civil Suits]. *Shimadai Hougaku 47. No.2* (2003): 25-78.

[21] "Saiban-in Seido 2 Nen [Two Years after the Implementation of the Saiban-in System]". *Yomiuri Shinbun*, May 20, 2011

[22] "Douro ni Deta Ball Sake Bike Tentou; Ketta Shounen gawa ni Baishou Meirei [A Bike Accident by Avoiding a Stray Ball on the Street]".*Yomiuri Shinbun*, June 28, 2011. http://osaka.yomiuri.co.jp/e-news/20110628-OYO1T00532.htm (Accessed June 30, 2011).

[23] "Soccer Ball Sake Tentou Shibou; Ketta Shounen no Oya ni Baishou Meirei [A Death Accident by Avoiding a Stray Ball and Fell down; an Compensation Order to the Parents of a Boy who Kicked the Ball]". *Asahi Shinbun*, June 28, 2011. http://www.asahi.com/national/update/0628/OSK201106280038.html (accessed June 30, 2011)

The Caffeine in Cold Medications is Not Sufficient to Promote Wakefulness

Manami Kawakami

Faculty of Pharmaceutical Sciences, Kyoto University

Abstract: Over-the-counter cold medications contain both antihistamine and anhydrous caffeine; the former causes drowsiness, and the latter improves wakefulness. However, many people feel sleepy after taking cold medicine. To explore this problem, we hypothesized that the amount of antihistamine in cold medications is enough to induce drowsiness but that the amount of anhydrous caffeine in the medications is not enough to counter these effects. We sought to verify this hypothesis by comparing the effects of cold medicines to the effects of other nonprescription drugs that contained only antihistamine or only caffeine. Through this comparison, it was revealed that the amount of antihistamine in the cold medications was enough to induce drowsiness, the amount of caffeine as not sufficient to counter these effects.

Key Words: cold medicines, sleepiness, caffeine, antihistamine

1. Introduction

Many people feel sleepy when they take cold medicines. These medications often contain both an antihistamine, such as chlorpheniramine maleate, and anhydrous caffeine; the former causes drowsiness, and the latter promotes wakefulness. To explain the drowsiness reported when taking cold medication, we hypothesized that the amount of antihistamine in cold medications is enough to make you sleepy but that the amount of anhydrous caffeine is not enough to counter these effects. This may be due to the exclusive selective action of antihistamines on the H1 receptor[1] in contrast anhydrous caffeine's effect is involved in some receptors[2]. Thus, even if a medication contains sufficient amounts of caffeine to produce the desired effect, it may not be enough to combat drowsiness. In this report, we sought to verify this hypothesis by calculation of the composition of cold medications and comparison of different medicines.

2. Methods

This research was based on a comparison between over-the-counter cold medications and other nonprescription medications, which contain chlorpheniramine maleate or anhydrous caffeine. This comparison presupposed that the medicines on the market included sufficient quantities of each component to ensure effectiveness. The purpose of our comparison was to verify whether the quantities of the antihistamine and anhydrous caffeine were sufficient to influence the level of alertness in the cold medications. The following were used for the comparison: three over-the-counter cold medications, three drugs containing only chlorpheniramine maleate, and three drugs containing only anhydrous caffeine. Because chlorpheniramine maleate affects only one receptor, its intended effect and its side effect (sleepiness) are both caused by the same interaction. By contrast, anhydrous caffeine targets several receptors. Therefore, its main and side effects (e.g., alertness) may be caused by different factors. Therefore formulations containing anhydrous caffeine are used in drugs to promote wakefulness. For this study, medications were selected that had an established dose and number of administrations. The three cold drugs were selected among popular over-the-counter drugs. For comparison, the top three hits for drugs containing "anhydrous caffeine" or "chlorpheniramine maleate" obtained by searching the Pharmaceuticals and Medical Devices Agency (Pmda)[3] web page were selected.

The comparisons between the three classes of drugs were made by obtaining the following information from the Pmda[3] web page:

(1) dose per administration
(2) number of administrations

Further, we acquired data on the half-life of chlorpheniramine maleate and anhydrous caffeine by referring to the Japanese Pharmacopoeia[4]. Using these data, we calculated the maximum concentration (Cmax) and the minimum concentration (Cmin) using a formula[1] detailed below to describe all the data collected on a single drug as one parameter. Although the effects of some drugs have no relationship with their Cmax or Cmin, for the purposes of this report, we presupposed that a connection did exist between the effect of the drugs and these parameters.

$$\text{Cmax} = \frac{A * \text{Dose}}{1 - \exp(-kT)}$$

$$\text{Cmin} = \text{Cmax} * \exp(-kT)$$

Here, "A" is a fixed number determined based on the drug composition. "Dose" represents the data for (1) or dose per administration, and its unit is a milligram. "T" is the administration interval in hours, which is equivalent to the number of administrations per day divided by 24 hours. The variable "k" is a quotient that is 0.693 divided by the half-life of the substance.

At the beginning of this section, we presupposed that "nonprescription drugs" were effective. We considered an effective

blood concentration to be any that was between the Cmax and the Cmin of the "nonprescription drugs". Accordingly, by determining the Cmax and Cmin of "nonprescription drugs" and cold drugs and through a comparison of these values parameters, it could be determined whether or not the active components of the drugs were present in effective doses.

3. Results and Discussion

3.1. Chlorpheniramine Maleate

The half-life of chlorpheniramine maleate was found to be 12-15 hours[4]. Table 1 shows the results of our investigation and calculations. Figure 1 shows the average Cmin/A and Cmax/A for chlorpheniramine malate. Black bars represent nonprescription drugs, and gray bars represent cold medications. As shown, the Cmax/A of the cold medications was 1.54 times larger than that of nonprescription drugs. Further, the Cmin/A of cold medications was 2.24 times larger than that of nonprescription drugs. We used the minimum values for comparison based on the supposition that the medications on the market contained enough chlorpheniramine to be effective. As a result, it can be concluded that the amount of chlorpheniramine maleate in cold medications is sufficient to induce drowsiness.

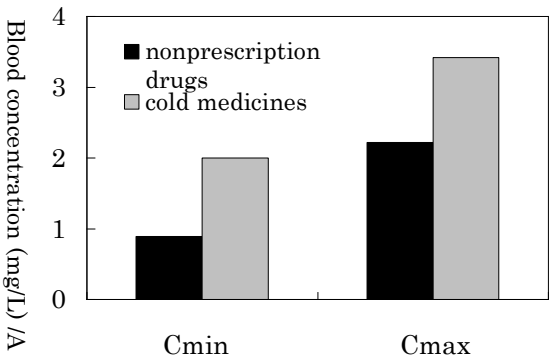


Figure 1: Comparison of chlorpheniramine maleate concentrations in medications

Table 1: Characteristics of drugs containing chlorpheniramine maleate

	Number*	Dose(d-CM)**	Cmin/A	Cmax/A
Cold medicines				
S. TAC EVE[5]	3	1.25 mg	2.13	3.38
New Contac Kaze Sogo[6]	2	1.75 mg	1.75	3.50
BENZA BLOCK L[7]	3	1.25 mg	2.13	3.38
Average			2.00	3.42
Nonprescription drugs				
Animing Syrup 0.04%[8]	1-4***	2 mg	0.67	2.67
Chlorpheniramine maleate syrup[9]	2-4	1-3 mg	1.00	2.00
Chlorpheniramine maleate powder[10]	2-4	1-3 mg	1.00	2.00
Average			0.89	2.22

*Number of administrations per day. **Dose per administration is described as the amount of d-chlorpheniramine maleate because only d-chlorpheniramine maleate has the capacity to induce sleepiness[4]. ***For calculation, we used the smallest value.

Table2: Characteristics of dugs containing anhydrous caffeine

	Number	Dose	Cmin/A'	Cmax/A'
Cold medicines				
S. TAC EVE	3	25mg	4.68	29.7
New Contac Kaze Sogo	2	37.5mg	2.50	40.0
BENZA BLOCK L	3	25 mg	4.68	29.7
Average			3.95	33.1
Nonprescription drugs				
"Junsei" Musui Kafein[11]	2-3	100-300 mg	6.67	107
Kafe Roppu[12]	3	167 mg	31.2	198
Daiyaru Moka[13]	3	167 mg	31.2	198
Average			23.0	168

3.2. Anhydrous Caffeine

The half-life of anhydrous caffeine was 3-6 hours[4]. Table 2 shows the results of our investigation and calculations. Figure 2 displays the plot of the average values of Cmin/A' and Cmax/A'. Black bars indicate nonprescription drugs, and gray bars indicate cold medications. In contrast to Figure 1, the Cmax/A' of cold medications was 0.20 times that of nonprescription drugs, and the Cmin/A' of cold medications was 0.17 times that of nonprescription drugs. These results indicate that the amount of anhydrous caffeine in cold medications is not sufficient to promote wakefulness.

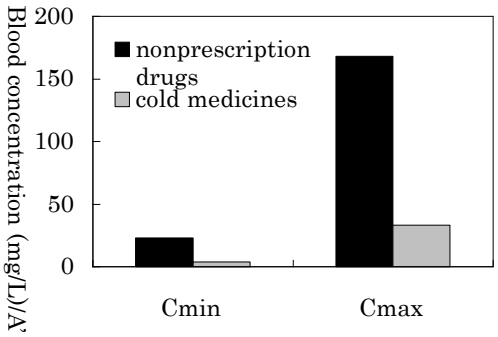


Figure 2: Comparison of concentrations of anhydrous caffeine between medications

4. Conclusions

The results of our study supported our initial hypothesis. While the amount of chlorpheniramine maleate in cold medications is enough to induce drowsiness, the amount of anhydrous caffeine is not sufficient to promote wakefulness.

This paper was based on the assumption that there was a connection between the Cmax and the Cmin values and the medications' effects as well as on the assumption that the over-the-counter drugs included sufficient amounts of each component. Future research should focus on experiments that require no such presupposition.

5. References

[1] *GOODMAN&GILMAN's THE PHARMACOL--OGICAL BASIS OF THERAPEUTICS (10 edition)*, 2003, To kyo, Hirokawa Publishing Company, 825-835, 34-37.

[2] Zhi-Li Huang, Wei-Min Qu, N.Eguchi, Jiang-Fan Chen, Michael A. Schwarzschild, Bertil B. Fredholm, Y. Urade, O. Hayashi. (2005). *Adenosine A_{2A}, but not A_1, receptors mediate the arousal effect of caffeine*, Nature Neuroscience, 8, 858-859.

[3] Pharmaceuticals and Medical Devices Agency, Pmda retr ieved from http://www.pmda.go.jp/
(access: 2011/09/12)

[4] T. Aoyama et al., eds, *The Japanese Pharmacopoeia 16th edition*, 2011, Tokyo, Hirokawa Publishing Company, C1516 -C1521, C1530-C1533, C1083-C1089.

[5] SSP CO.,LTD, S.TAC EVE, retrieved from http://www.ssp.co.jp/product/all/ste-t/ (access:2011/10/29)

[6] GlaxoSmithKline plc, New CONTAC Kaze-Sogo retrieved from http://contac.jp/products/con_sin_sougou.html (access: 20 11/07/24)

[7] Takeda Pharmaceutical Company Limited, BENZA BLOCK L retrieved from http://takeda-kenko.jp/produ cts/kaze/bbl.html
(access: 2011/09/12)

[8]Nissin Pharmaceutical Co., LTD, **Animing Syrup 0.04% retrieved from http://www.info.pmda.go.jp/go/pac k/4419002Q1117_1_01/ (access: 2011/09/12)

[9] NIPRO Pharma Corporation, Chlorpheniramine maleate sy rup retrieved from http://www.info.pmda.go.jp/go/pack/4419001 Q1104_1_01/
(access;2011/10/29)

[10] ISEI Co., Inc, Chlorpheniramine maleate powder retrieved from http://www.info.pmda.go.jp/go/pack/441 9003B1330_1_01/ (access:2011/10/29)

[11] Junsei Pharmaceutical Co., LTD, "Junsei" Musui Kafein retrieved from http://www.info.pmda.go.jp/go/pack/2115009X10 20_1_07/
(access:2011/10/29)

[12] DAIICHI SANKYO HEALTHCARE Co., LTD, Kafe Ro ppu retrieved from http://www.info.pmda.go.jp/ogo/J060100168 2_02_01 (access:2011/10/29)

[13] JPS Pharmaceutical Company, Daiyaru Moka retrieved from http://www.info.pmda.go.jp/ogo/J0607000 790_02_01 (access:2011/10/29)

Future Prospects of Nuclear Fusion Energy

Masayuki Homma

Faculty of Engineering, Kyoto University

Abstract: The accident at the Fukushima No.1 Nuclear Power Plant has given us the chance to stop and think about the problem of our future energy system. Nuclear fusion energy, which is released in the process of nuclei binding to form heavier nuclei, can be a long-term candidate for future power generation. Fusion energy could be competitive with other prospective energy sources in terms of i) safety and reliability, ii) cost effectiveness, iii) abundance of the energy resource, iv) stability of the energy supply, and v) environmental impacts. It would be gradually introduced after approximately 2055 and account for a certain part of the domestic electricity generation in the latter half of this century. Although it is not yet well known to the general public, nuclear fusion is one of the most promising energy technologies for the future.

Key Words: fusion energy, nuclear power

1. Introduction

On 11 March 2011, a massive earthquake and tsunami caused extensive damage to Fukushima No.1 Nuclear Power Plant, which resulted in the release of harmful radiation. Nuclear fission power has traditionally played a key role in the history of electricity generation in Japan. However, the catastrophe in Fukushima revealed once again its inherent danger as an energy source and gave us an opportunity for more thoughtful discussion of a future energy system.

Meanwhile, the global warming caused by the excessive use of fossil fuels remains an issue of concern. In addition, the problem of growth of energy demand is also controversial. Therefore, we should invest in finding alternative energy sources.

Nuclear fusion energy can be a possible solution to these problems. When two nuclei from light atoms are forced to bind together under high temperatures, they will fuse and release enormous amounts of energy. There are several types of fusion reactions, and the most promising one is that between the hydrogen isotopes D and T. The reaction formula can be expressed as follows:

$$D + T \rightarrow He(3.5\ MeV) + n(14.1\ MeV)$$

D stands for deuterium (the stable isotope of hydrogen that contains one proton and one neutron), and T stands for tritium (the radioactive isotope of hydrogen that contains one proton and two neutrons).

The reaction products are α- particles (helium nuclei) and highly energetic neutrons. The emitted neutron carries away a large part of the heat in the form of extremely high amounts of kinetic energy. Then, the heat is converted into electric power.

Nuclear fusion has been intensively investigated in the ITER (International Thermonuclear Experimental Reactor) in the south of France. To date, however, nuclear fusion technology has not yet been developed enough to be commercialized. To initiate and sustain a fusion reaction, the fuel must be raised to temperatures of 100,000,000 ℃. Considering such a technical difficulty, it is expected that fusion energy will become practical in approximately 2050.

In my study, a combination of literature reviews, expert interviews, and questionnaire surveys was adopted. This paper will discuss I) the main attributes of fusion energy, II) the scenario for the introduction of fusion energy, and III) the public attitude toward fusion energy.

2. The Main Attributes of Fusion Energy

2.1. Safety and Reliability

It is assumed that nuclear fusion is associated with a relatively high level of safety. There are several reasons for this assumption.

In nuclear fusion, there is no risk of a runaway accident. Unlike fission, the fusion reaction is not based on a neutron multiplication reaction, and therefore, in principle, criticality accidents are not expected to occur.

Another reason is the absence of high-level radioactive waste. In nuclear fission, generation of radioactive waste is unavoidable because the reaction products are highly radioactive. In contrast, nuclear fusion generates no high-level radioactive waste.

However, a small amount of low-level radioactive waste is produced in nuclear fusion. The inside wall of the reactor becomes radioactive during operation due to the energetic neutrons, and it must be regularly replaced.

In addition, tritium fuel is a radioactive substance with a half-life of 12.3 years. Although tritium is considered less hazardous, it should be properly handled to prevent unnecessary radiation exposure.

2.2. Cost Effectiveness

The cost of fusion power has been widely discussed, but much ambiguity remains.

Okano et al. [1] have presented estimates of a possible target cost of a first-generation commercial fusion plant. In their study, they indicate that less than 10 yen/kWh is desirable, and even if impossible to attain, 15 yen/kWh is the upper limit.

Figure 1 below compares the electricity costs for different

generation technologies. The information, except the estimated cost of fusion energy, is based on Japan's Energy White Paper [2].

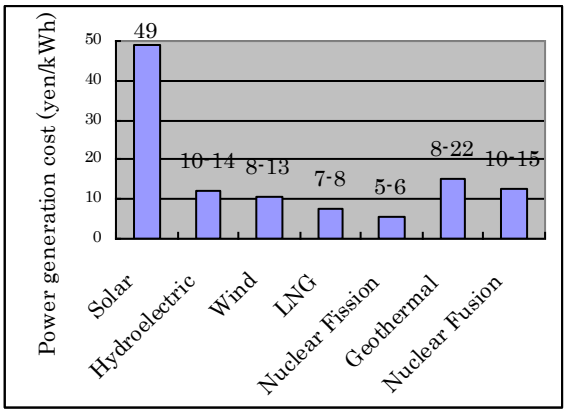


Figure 1: Comparisons of electricity generation costs of nuclear fusion and other energy sources

As a matter of course, there is much uncertainty in the power generation cost estimates for each type of energy source in 2050, the point at which fusion energy is estimated to be commercialized. As oil reserves are depleted, the prices of oil will rise continuously with increasing scarcity. What is more, cost reductions for solar and wind power associated with technological innovation are expected in the future. However, fusion energy does have the potential to become economically competitive with other sources.

2.3. Abundance of the Energy Resource

It is assumed that fusion energy would provide a practically inexhaustible resource because the fuel supply is widely available. Deuterium exists abundantly in the ocean. Tritium can be bred from lithium using neutrons within the reactor, and lithium is available from land deposits or from the ocean.

2.4. Stability of the Energy Supply

Needless to say, unlike solar and wind energy, fusion power operation is not reliant upon weather conditions and the time of day.

Additionally, as mentioned in the last section, the fusion fuel supply is virtually unlimited, and the fuel cycle can be completed in a single reactor.

For these reasons, fusion energy has enough capability for use as a stable energy supply.

2.5. Environmental Impacts

Tokimatsu [3] calculates that the amount of CO_2 emitted from fusion reactors is 22.2-43.9 g-CO_2/kWh. In Figure 2, the CO_2 emissions for fusion power are compared with emissions from sources including fossil fuel power and fission power. The information, except for the fusion power data, is based on the CRIEPI Research Report [4].

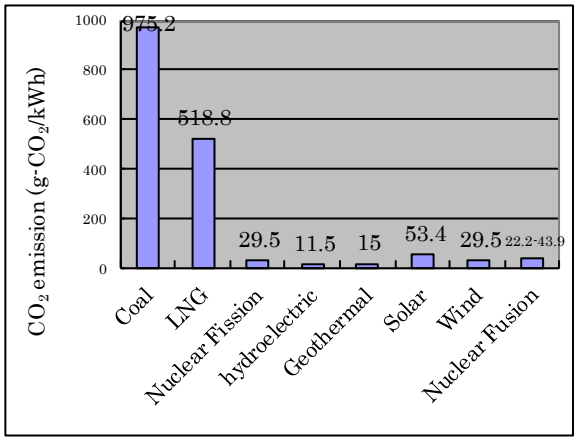


Figure 2: Comparisons of CO_2 emissions from a fusion reactor and other electricity generation systems

As the figure above shows, fusion power is one of the large-scale energy sources that has a lower level of CO_2 emissions.

Though a fusion reactor would not be free of radioactive waste, the waste from the fusion reaction is considered to be easier to dispose of than fission wastes. According to Muroga [5], the cost for disposal of radioactive waste in nuclear fusion is estimated to be 10% ~ 30% of that of nuclear fission.

For the above-mentioned reasons, it is suggested that fusion is a relatively eco-friendly form of energy.

3. The Scenario for the Introduction of Fusion Energy

3.1. The Projection by JAEA

A literature review was conducted on data related to the future of fusion energy. I referred to Nuclear Energy Vision 2100 [6], published in 2008, which shows an energy demand and supply scenario for the year 2100 in Japan, to obtain the projection made by JAEA (Japan Atomic Energy Agency) regarding the future development of nuclear fusion. In this section, the results of my review will be discussed.

JAEA's 2008 projection of future fusion capacity is shown in Figure 3. As seen in Figure 3, nuclear fusion is introduced gradually during the first 20 years after 2055 in steps of 4 GW/10 years, following which there is an accelerated pace of capacity additions. As a result, it is forecasted that 33 fusion reactors (1 GW/unit) will have been built in Japan by the year 2100.

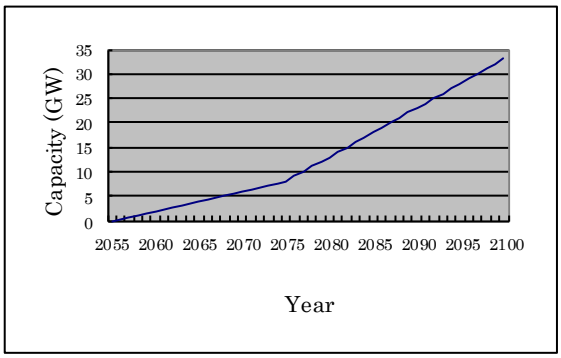


Figure 3: Scenario of introduction of nuclear fusion reactors projected by JAEA

In Figure 4 below, JAEA's estimate of future fusion growth is compared with the historical growth in nuclear fission power plants. The historical data are based on The Nuclear Almanac [7][8][9][10]. As seen in Figure 4, the pace of introduction of nuclear fusion seems much slower than that of nuclear fission. The structural complexity of fusion reactors might be partly responsible for this gap.

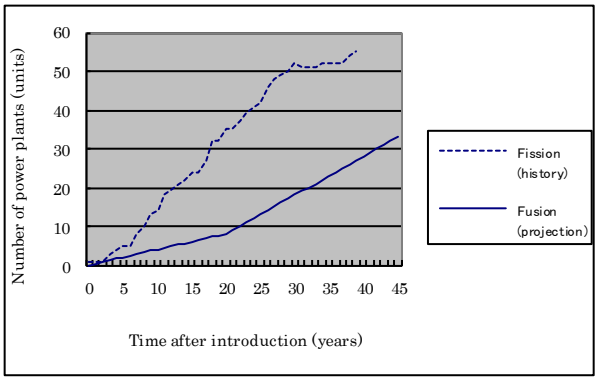


Figure 4: Pace of introduction of fission plants (history) and fusion plants (projection)

JAEA's projection also indicates that nuclear fusion can supply 14% of the total electricity output in Japan in 2100. The 2008 projected breakdown of electricity generation in 2100 is shown in Figure 5. In this figure, nuclear fission power, including FBRs (fast breeder reactors), accounts for 53% of Japan's electricity production in 2100.

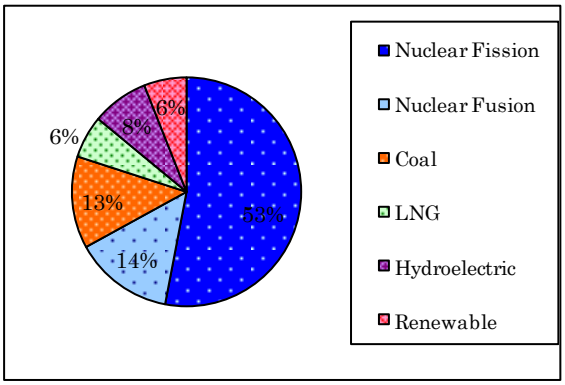


Figure 5: Projected breakdown of electricity generation in 2100

3.2. The Effect of the Fukushima Accident

I conducted an e-mail interview with an expert, Prof. Kazuya Takahata, from NIFS (National Institute for Fusion Science) on September 25, 2011, and personally asked him for his views on whether the Fukushima accident would affect the future study of fusion. In this section, the expert's opinion will be analyzed.

As mentioned in the last section, JAEA anticipated in 2008 that nuclear power would supply approximately two-thirds of the domestic electricity requirements in the year 2100. However, in reality, in the wake of the disaster at Fukushima in March of 2011, the nuclear share of electricity generation would be far smaller than JAEA's projection made in 2008. Takahashi and Nagata [11] estimate that the share of electricity generated from nuclear energy would drop from 38% in 2010 to 14% in 2030 if all the newly proposed power plants were cancelled, as shown in Figure 6.

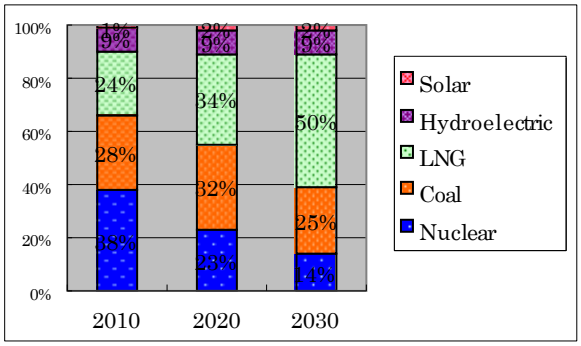


Figure 6: Estimated shares of nuclear power and other energy sources (after Fukushima)

Will this have an influence on the research work being conducted on nuclear fusion? Prof. Takahata from NIFS answered this question. His argument is as follows:

> The introduction year of nuclear fusion would not be earlier than 2050 because the projection "commercial fusion by 2050" is based on the premise that all the steps in the project would go smoothly. However, research work on FBR is likely to come to a halt, and some of the enormous investment in FBR might be switched into the research budget for nuclear fusion. In that event, it could be possible to introduce fusion energy in accordance with ITER's scenario.
> (K. Takahata, personal interview. 25 Sep. 2011)

Furthermore, in terms of the scenario of the development of nuclear fusion, he made the following statement:

> The future growth rate of nuclear fusion would not depend upon the anti-nuclear power trend or the amount of fossil fuel reserves, but upon the effects of climate change around 2050. With environmental degradation, the share of fusion energy might increase to 20% (40 units).
> (K. Takahata, personal interview. 25 Sep. 2011)

Indeed, the Fukushima accident will adversely affect the research work on the Monju FBRs due to the intense concern regarding its safety. The Japan government says that funding for research on the Monju FBRs will be cut by 70% ~ 80% next year. However, its effect on the study of fusion will be limited because the investigation of nuclear fusion is not being worked on exclusively by Japan but rather is an international collaboration among various nations.

4. The Public Attitudes toward Fusion Energy

4.1. Methods

In October 2011, a brief street intercept questionnaire survey was

administered in various public places located in Kyoto and Osaka Prefecture. Subjects were randomly selected: 17 nonprofessional adults aged 20-50 years (10 males and 7 females) were surveyed. No respondent names or other individual identifiers were collected.

The questionnaire was divided into two parts. The questions included the rating of the importance of various features for energy sources and their familiarity with nuclear fusion. First, respondents were asked to rank in order the importance of five different requirements for future energy technologies: i) safety and reliability, ii) cost effectiveness, iii) abundance of the energy resource, iv) stability of the energy supply, and v) environmental impacts. Second, respondents were asked if they knew about nuclear fusion. If a negative response was given, the question was followed by asking about their first impression of the term "nuclear fusion."

4.2. Results

The survey was conducted at three different public places in the Kyoto and Osaka area, and a total of 17 successful responses were achieved.

Given the five factors required for energy technologies, the respondents were asked to rank the factors according to what they believed was most important. Figure 7 presents the proportions of respondents who chose each factor as their top priority.

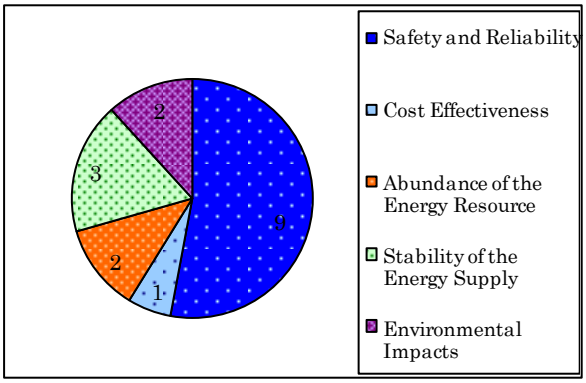


Figure 7: Proportions of respondents who chose each factor as their top priority

I gave the highest priority factor a score of five and the lowest priority factor a score of one. The scoring scale is represented as follows: (priority, score) – (1,5), (2,4), (3,3), (4,2), (5,1). The average scores for each factor are shown in Figure 8.

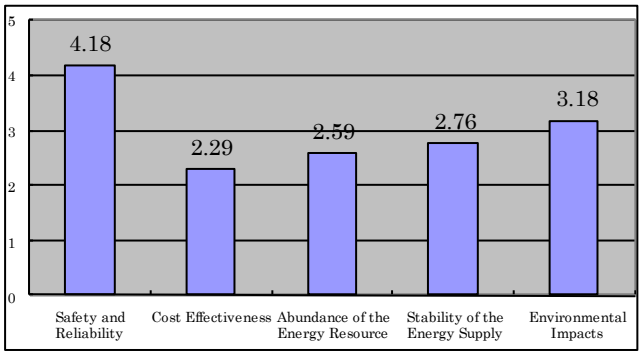


Figure 8: Average scores of priority for each factor

Only 2 respondents said yes when asked whether they knew about nuclear fusion (Figure 9). Of the 15 respondents with little or no familiarity with "nuclear fusion," 7 respondents indicated that they had a negative reaction to the term (Figure 10).

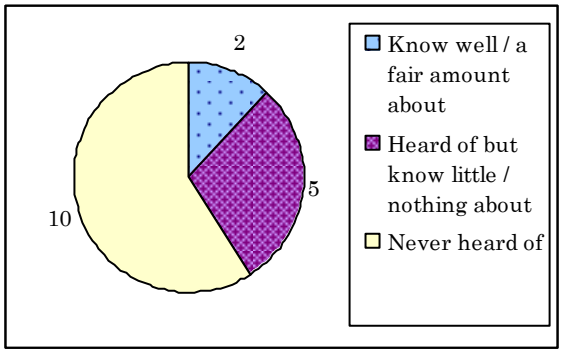


Figure 9: Respondents' knowledge about nuclear fusion

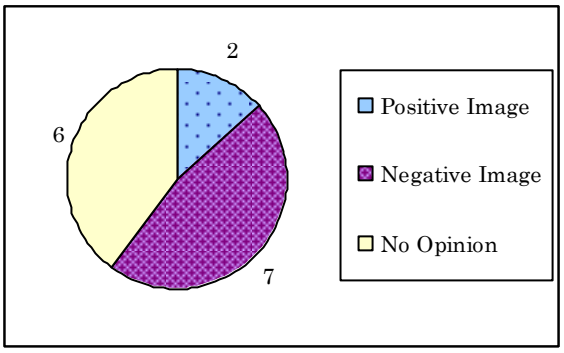


Figure 10: Respondents' first impression of the term "nuclear fusion"

4.3. Discussion

It is clear that the validity of this questionnaire is limited because the sample size is too small, but the results seem clear enough to provide a picture of the basic situation.

To the first question, a large majority of respondents regarded "safety and reliability" as the top priority, and "environmental impacts" obtained the second highest score. From these results, it can be inferred that development of safe and reliable techniques for radioactive control would be essential if fusion were to gain major public support.

The result of the second question suggests that nuclear fusion is not well known to ordinary people. Moreover, in the last question, many female respondents stated "nuclear fusion" sounds very dangerous. Some Japanese people, living in the only country ever attacked by nuclear bombing, might be hypersensitive to the word "nuclear." Therefore, it might be effective to rename it to something more socially acceptable, such as "hydrogen fusion."

5. Conclusions

Today the energy situation is in flux in the wake of the Fukushima disaster, and finding alternative energy sources is of vital importance to our future. Nuclear fusion could be the ultimate solution to the current energy crisis. In this paper, I have discussed the future prospect of fusion energy. The summary is as follows:

- Fusion energy has many favorable properties. Fusion energy would be comparable to other prospective resources in terms of i) safety and reliability, ii) cost effectiveness, iii) abundance of the energy resource, iv) stability of the energy supply, and v) environmental impacts.
- JAEA predicted in 2008 that the number of fusion power plants would gradually increase after approximately 2055. According to one expert, the Fukushima accident might have little influence on the study of fusion.
- The result of the questionnaire survey suggests that more reliable technology must be developed. It also implies the low recognition of the term "nuclear fusion" and the necessity for the use of an alternative term.

The deuterium-tritium reaction is the least difficult fusion reaction, but it produces radiation in the form of neutrons. By using helium-3 gathered from the moon, the radiation produced could be dramatically reduced. However, the helium-3 reaction requires up to ten times the temperatures of the deuterium-tritium reaction. In my future research, I would like to examine the possibility of using the helium-3 fusion reaction.

6. Acknowledgements

I wish to acknowledge valuable discussions with Prof. K. Takahata from NIFS. I would also like to thank all the respondents to the questionnaire for their kindness.

7. References

[1] Okano, K. *et al.* (2005). Path toward Commercial Fusion Power Plants. *Journal of Plasma and Fusion Research*, *81*(11), 839-848.

[2] METI Ministry of Economy, Trade and Industry (2010). *Energy White Paper 2010*, June 2010.

[3] Tokimatsu, K. (2002). Expected Effect of Fusion Reactor on Global Environment: Nuclear Fusion as a Global Warming Mitigation Technology. *Journal of Plasma and Fusion Research*, *78*(11), 1186-1191.

[4] Hondo, H. *et al.* (2000). Evaluation of Power Generation Technologies based on Life Cycle CO_2 Emissions. *CRIEPI Research Report.*

[5] Muroga, T. (1998). Radioactive Waste. *Journal of Plasma and Fusion Research*, *74*(8), 802-807.

[6] JAEA Japan Atomic Energy Agency (2008). *Nuclear Energy Vision 2100*, October 2008.

[7] JAIF Japan Atomic Industrial Forum (1980). *The Nuclear Almanac 1980*, September 1980.

[8] JAIF Japan Atomic Industrial Forum (1990). *The Nuclear Almanac 1990*, October 1990.

[9] JAIF Japan Atomic Industrial Forum (1996). *The Nuclear Almanac 1996*, October 1996.

[10] JAIF Japan Atomic Industrial Forum (2005). *The Nuclear Almanac 2006*, October 2005.

[11] Takahashi, M., & Nagata, Y. (2011). *SERC Discussion Paper 11022.*

Japanese Attitudes toward Genetic Engineering

Sanae Izumi[1], Hitoshi Mori[2], Satoshi Kusaba[3], Takuya Okada[4], Tomo Murayama[1], Takuya Yamamoto[3]

[1]Faculty of Pharmaceutical Sciences, Kyoto University,
[2]Faculty of Agriculture, Kyoto University,
[3]Faculty of Science, Kyoto University,
[4]Faculty of Medicine, Kyoto University

Abstract: Whether or not the general public supports biotechnology and genetic engineering is an important current problem. In this paper, we report that people's attitudes toward the terms "biotechnology" and "genetic engineering" are highly dependent upon their knowledge of the fields. For this reason, it is necessary to promote activities that provide the general public with information on the current states of biotechnology and genetic engineering so that they can form educated opinions.

Key Words: biotechnology, GM (genetically modified) foods

1. Introduction

Many people starve to death because they are unable to grow enough crops in their impoverished countries. Food shortage has become one of the most serious problems in the world. Some people expect that genetic engineering can solve this problem because genetically modified plants can grow more easily in barren land [1].

However, some people worry that genetically modified foods may do harm to our health and the environment. It is often reported that Japanese people tend to avoid genetically modified foods. Sure enough, previous surveys of attitudes toward genetic engineering showed that, in Japan, more people had "negative" or "neutral" opinions regarding genetically modified foods than people in other nations.

These findings piqued our interest in the Japanese public's views on genetic engineering and made clear to us the importance of active discussion on the subject of genetic engineering. In conjunction with other university students in Japan, we designed questionnaires asking for subjects' impressions of genetic engineering and carried out a nationwide survey in order to clarify the reasons for Japanese people's attitudes toward the subject [3].

In this paper, we suggest that educational differences have created a gap between the attitudes of students and adults of their parents' generation.

2. Methods

We carried out our attitude survey with 5 Japanese iGEM (the International Genetically Engineered Machine competition) teams: Osaka, KIT-Kyoto, Tokyo Metropolitan and UT-Tokyo. We all used the same paper-based questionnaires in all locations.

2.1. Terms and Places

We conducted this survey from June 30 to September 26, 2010, in areas near our universities. We distributed and collected the questionnaires from students from July 12 to September 26, 2010 at Kyoto University. The non-student surveys were conducted on August 28 and 29 at Masukata Shopping Street and on September 11 and 12 at the Coop Shimogamo. All sites are located in Kyoto city, Japan.

2.2. Questionnaires

We prepared two questionnaires, "Attitude Survey of Genetic Engineering" and "Attitude Survey of Biotechnology." We interchanged the terms "genetic engineering" and "biotechnology" in order to assess subjects' different associations with these two terms.

2.3. Search of "Biotechnology" and "Genetic Engineering" in Japanese in Google

On October 31, 2010 we performed a Google search of these terms in Japanese.

3. Results

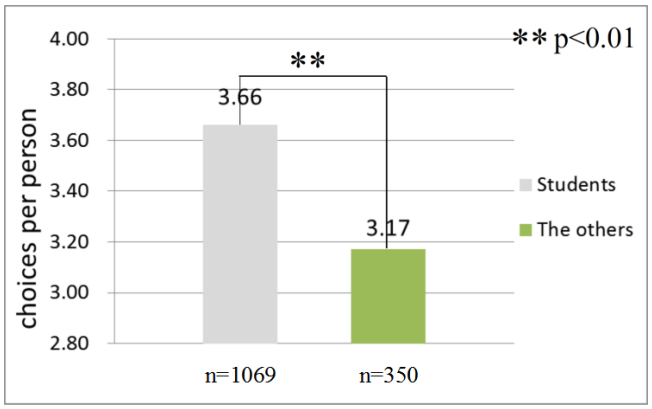
We obtained 1,511 answers in total: 955 from students and 556 from non-students—primarily adults of the students' parents' generation. These data are analyzed in 3.1., 3.2. and 3.3. We also focused on the change in the government's curriculum guidelines.

In this paper, we regard "genetic engineering" and "biotechnology" as the same unless we distinguish them explicitly.

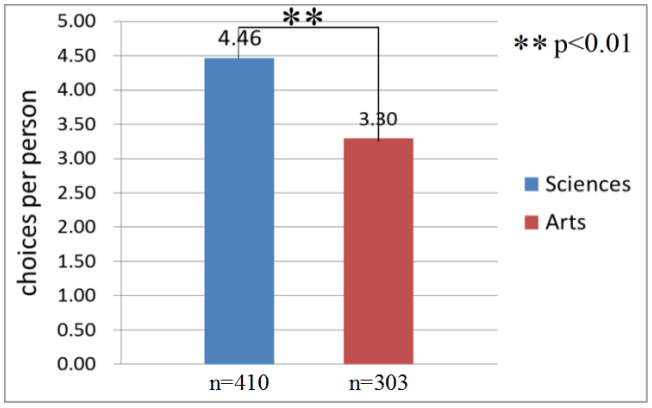
3.1. Knowledge of the Subjects

We assumed that the subjects' knowledge of biotechnology would influence their attitudes toward it. In order to confirm this assumption, we investigated how many words associated with biotechnology they knew. We supposed that the more words they know, the more knowledge of biotechnology they have. First, we compared the students with adults of their parents' generation. Figure 1-A shows that the students have more knowledge than adults of their parents' generation ($p<0.01$). Second, we compared science students with arts students. Figure 1-B shows that the science students have more knowledge than the arts students

(p<0.01).



A: Students vs. Others



B: Sciences vs. Arts

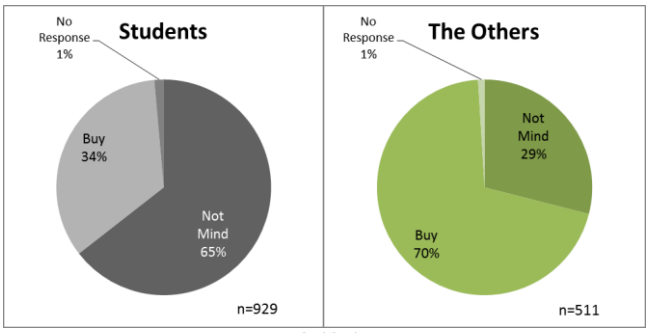
Figure 1-A, B: These figures show the results of Q2: "What do you associate with (genetic engineering / biotechnology)? (※ Please circle all that apply)."

3.2. The Differences among Subjects' Attitudes

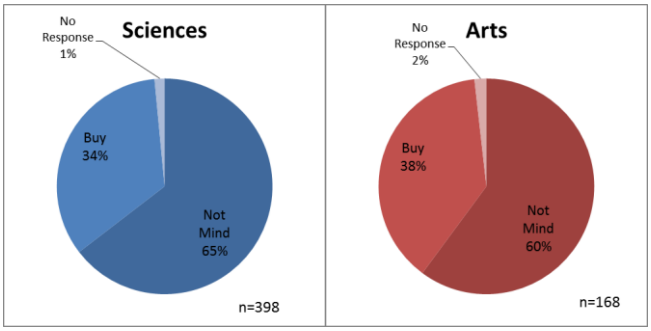
In Japan, arts and sciences classifications are important. Most Japanese students learn different subjects beginning in high school, depending on their classification, because the entrance examinations of colleges and universities are specific to either arts (literature, law, etc.) or science (engineering, medicine, etc.). For this reason, we expected that there might be some differences between the attitudes of arts students and those of science students.

The subjects who were not students were primarily adults of the students' parents' generation. Our survey showed that the others tend to buy non-genetically modified foods more often than students do (Figure 2-A). Also, our survey showed that arts students tend to buy non-genetically modified foods more often than science students (Figure 2-B).

We also surveyed subjects' opinions on artificial genetic mutation. These responses showed similar results. Students were more likely to feel positively about artificial genetic mutation than the others were, and science students were more likely to allow artificial genetic mutation than arts students were. The results of our survey are consistent with previous surveys about genetic engineering [3][7].



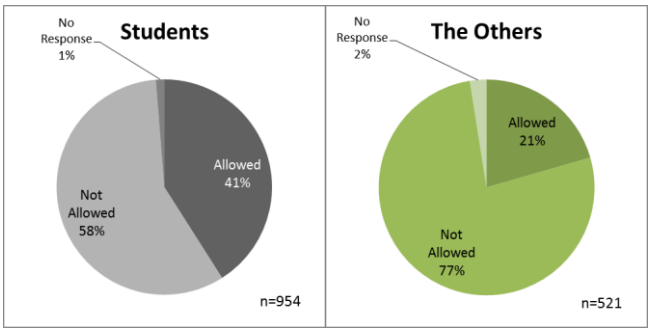
A (Q1)



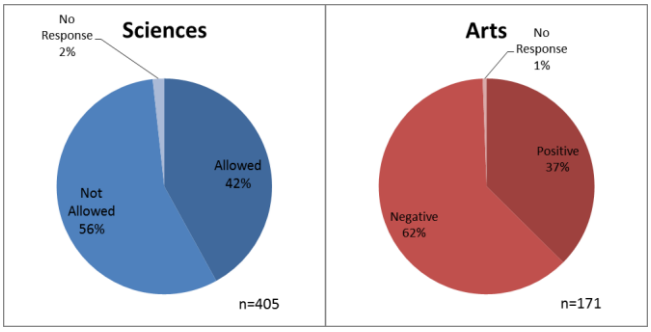
B (Q1)

Figure 2-A, B: Attitudes toward "Non-genetically Modified Foods"

These figures show the results of Q1: "When shopping do you buy 'non-genetically modified foods'?" The "Buy" category represents subjects who answered, "not mind so much" and "never mind."



A (Q4)



B (Q4)

Figure 3-A, B: Attitudes toward Artificial Genetic Mutation

These figures show the results of Q4: "What do you think about artificial genetic mutation through (biotechnology / genetic engineering)?" The "Allowed" category represents subjects who answered "OK" and "not bad." The "Not allowed" category

represents subjects who answered “not good” and “bad.”

3.3 The Difference between Biotechnology and Genetic Engineering

The subjects who were science students tended to exhibit a positive attitude toward genetic engineering. They may have relatively more knowledge of genetic engineering than subjects who are arts students or others. Thus, we predicted that the amount of knowledge one has of genetic engineering has a great impact on one’s attitudes toward genetic engineering.

To confirm this hypothesis, we performed a Google search of the terms “biotechnology” and “genetic engineering.” Figure 4 shows the result: “biotechnology” is used more often than “genetic engineering.” Table 1 shows that subjects’ attitudes toward “biotechnology” are more positive than those toward “genetic engineering”.

These findings show that subjects’ knowledge of biotechnology or genetic engineering has a great impact on their attitudes toward these fields.

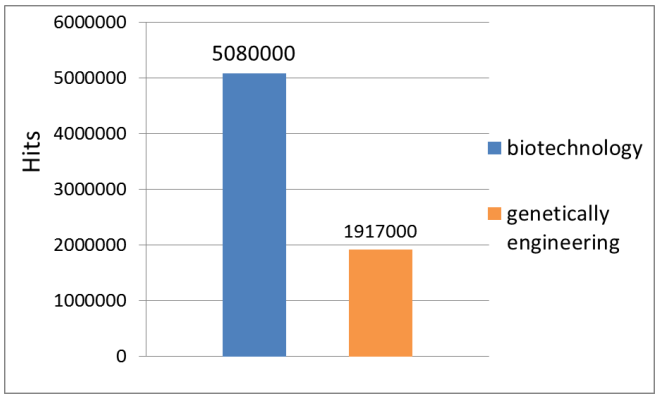


Figure.4: Comparison of the Number of Websites that Contain the Words “Biotechnology” and “Genetic Engineering” in Japanese

This figure shows the number of Google search results for the terms “biotechnology” and “genetic engineering” in Japanese.

Table.1: Differences among Attitudes (Q4, 7)

Q4			Q7		
	Negative	Positive		Negative	Positive
Biotechnology	57.3	41.9	Biotechnology	8.8	88.5
Genetic Engineering	65.8	32.2	Genetic Engineering	13.6	82.5

This table is the result of Q4 and Q7. (Q4 is “What do you think about artificial genetic mutation by (biotechnologies / genetic engineering)?” and Q7 is “Do you think that the research on (biotechnology / genetic engineering) should be continued?”) In Q4, “Negative” represents subjects who answered “OK” and “not bad,” and “Positive” represents subjects who answered “OK” and “not bad.” In Q7, “Negative” includes subjects who answered “the research should not be continued” and “Positive” includes subjects who answered “the research should be continued.” 1259 subjects answered Q4 and Q7.

3.4. The Governmental Curriculum Guideline

Given the results in 3.3., we believe that amount of knowledge can account for the difference in attitudes. As stated above, subjects consisted primarily of students and adults of their parents’ generation. To confirm the difference in the amount of knowledge between the two groups, we looked up words that were included in the choices for Q2. A chapter on biotechnology doesn’t exist in the government’s curriculum guidelines for high schools in 1978 and 1989. However, the chapter does exist in the 1999 and 2009 guidelines.

We then counted the number of the words related to biotechnology and genetic engineering found in textbooks over a range of years [2][5][6]. The results are described in Table 2. From these results, we saw that the number of words has increased over time.

Table 2: Number of Words in Textbooks[2,5,6]

Year	1962	1985	2006	Year	1962	1985	2006
Clone	0	0	13	Virus	0	3	19
GM crops(foods)	0	0	1	Artificial life	0	0	0
Patent	0	0	1	Nobel Prize	0	2	0
DNA	0	86	176	Environment	58	42	38
Genome	0	0	11	Biological weapon	0	0	0
Medicine	0	15	4	iPS cell, ES cell	0	0	6
Cosmetic	0	0	0	Biofuel	0	0	0
Bioethics	0	1	0	Biohazard	0	0	0

This table shows the number of words related to biotechnology and genetic engineering found in textbooks from 1962, 1985 and 2006. The results show that there are significant differences between past and present textbooks.

3.5. Words Associated with Biotechnology and Genetic Engineering

In addition to counting the words associated with biotechnology and genetic engineering that were found in textbooks, we also looked at the words subjects associated with the two terms.

Table 3: The Proportion of Choices (%) (Q2)

Clone	56.1	Virus	9.8
GM crops(foods)	71.0	Artificial life	14.0
Patent	7.0	Nobel Prize	5.6
DNA	52.9	Environment	11.8
Genome	24.4	Biological weapon	9.9
Medicine	13.3	iPS cell, ES cell	22.7
Cosmetic	5.0	Biofuel	12.7
Bioethics	22.6	Biohazard	9.3

Table 3 shows the results of Q2: “What do you associate with (genetic engineering / biotechnology)? (※Please encircle all that apply.)” This result shows that people tend to think “clone,” “GM crops (foods)” and “DNA” are words associated with biotechnology and genetic engineering. 1057 people answered to this question.

3.6. Conflicting Opinions on Genetic Engineering Research

We have shown that one of the reasons for Japanese people’s negative or neutral attitudes toward genetic engineering is their lack of knowledge. We also sought other reasons for these attitudes. Table 4 shows that the reasons why some subjects support biotechnology research oppose the reasons why others oppose it. This finding suggests that people may have both positive and

negative ideas about the results of genetic engineering, so they cannot accept genetic engineering easily.

Table 4: Reasons for Believing that Research Should (or Should Not) Be Continued (Q7)

Should Continue		Should Not Continue	
solution to food crisis	63.8	harmful to environment and humans	56.9
solution to environmental problems	42.3	harmful to ecosystem	62.1
solution to energy problem	38.9	harmful to human body	53.8
application to medicine	63.3	unethical	31.8
a business opportunity	19.5	people say dangerous	5.1
preservation of the species	15	application to evil use	27.2
development of science	17.8	not enough laws	15.9
practical use in many countries	6.7	replication with other technologies	6.2
many possibilities	41.1	less potential	1.0
interesting as an academic	22.4	somehow uneasy	26.7
others	2.1	others	2.1

This table shows the results of Q7: "Do you think that the research on (biotechnology / genetic engineering) should be continued?" 1259 people answered to this question.

4. Discussion

4.1. The Correlation between Knowledge and Attitude

(1) Differences in Knowledge Depending on Subjects

The answers to Q2, "What do you associate with (biotechnology / genetic engineering)?" can be used to indicate subjects' amount of knowledge of biotechnology and genetic engineering. Thus, Figures 1-A and B reflect each group's amount of knowledge of these subjects. Students, especially science students, were more familiar with biotechnology and genetic engineering than arts students and adults of their parents' generation. The difference in amount of knowledge may be attributed to the change in the government's education curriculum. The older generation has not been educated on more recent developments in the life sciences. Likewise, arts students generally have fewer opportunities to learn about biotechnology and genetic engineering than science students do.

(2) Differences in Attitudes Depending on the Subjects

In Figures 2 and 3, it shows that students are less inclined to have negative attitudes toward biotechnology and genetic engineering than adults of their parents' generation. It also showed that arts students are more inclined to avoid biotechnology and genetic engineering than science students.

Considering the results of both (1) and (2), we suggest that people less familiar with the terms "biotechnology" and "genetic engineering" are more likely to consider the products of these fields to be unknowable and to have possibly harmful effects.

4.2. Reasons for Subjects' Avoidance of Biotechnology or Genetic Engineering

Table 1 shows that genetic engineering had a more negative reputation than biotechnology. In Q2 (Table 3), "GM foods (crops)," "clone" and "DNA" were chosen often as words associated with genetic engineering and biotechnology. These words are popular news topics and are directly associated with the word "gene." Thus, these words may have a significant influence on the differences in people's attitudes toward genetic engineering.

As seen on the left side of Table 4, the three most popular reasons chosen for why "the research should be continued" were "usefulness for food crisis," "application to medicine" and "solution of environmental problems." As seen on the right side of Table 4, the three most popular reasons chosen for why "the research should not be continued" were "harmfulness to the ecosystem," "harmfulness to human and environment" and "harmfulness to human body." These responses are contradictory. From these contradictions, it is evident that people have both worries and hopes for biotechnology and genetic engineering. Providing lectures about genetic engineering that increase people's knowledge of the subject can alleviate their worries and encourage more positive attitudes toward genetic engineering.

5. Conclusions

We investigated the reasons for the significant difference between the opinions of students and those of their parents' generation, and we suggested that one of the reasons for this difference was the education gap. Twenty years ago, for instance, the field of molecular biology was immature, and new technologies like genetic engineering were just beginning to develop. Thus, only scientific experts or those with experience in the field of biology may have been familiar with those new fields such as genetic engineering. Therefore, most older adults are unfamiliar with genetic engineering and as a result, tend to avoid genetically modified foods. Meanwhile, biotechnology has developed, and the amount of information about genetic engineering in textbooks has increased dramatically. As a result, current students can more easily assess the advantages and disadvantages of genetic engineering and make an informed decision about whether they support it.

In this study, we find that many people think genetic engineering research should be continued and expect the research will solve both the food crisis and health problems. At the same time, there are also many people who worry about genetic engineering and require more information about the safety of genetic engineering and better explanations of the scientific terms associated with the field. With these conclusions, we suggest that it is important to encourage science communication between scientists and adults of the older generation so that the adults can know the field deeply. In fact, there are already some organizations delivering lectures about genetic engineering and genetically modified foods, among other subjects. For example, "Let's Study Bio Lecture" was held in Shiga and "Science Agora" was held in Tokyo. In fact, the data on "Let's Study Bio Lecture" show that lectures are very effective through questionnaire research [4][7]. There are still only a small number of lectures being held, so it is necessary to increase the number of lectures on genetically modified foods so that people can gain sufficient knowledge of the current issues regarding genetic engineering. To carry out this educational project, scientists' support is essential. However, most scientists are reluctant to deliver lectures on genetic engineering. Perhaps they want to concentrate on their own studies. We suggest that scientists with enough knowledge of genetic engineering should play an important role in communicating with other scientists and the general public. They can define difficult scientific terms and discuss how the field

of genetic engineering has changed over time so that those whom they teach will gain sufficient knowledge of genetic engineering.

6. Acknowledgements

We thank the respondents of the questionnaires and all iGEM teams that convened on this project: the Osaka, KIT-Kyoto, Tokyo Metropolitan, and UT-Tokyo teams.

7. Supplementary Information

Supplementary information is available online at http://2010.igem.org/Team:Kyoto/HumanPractice

8. References

[1] Aislinn, S. GM cereal crops created to grow in salty water. (2009, Jul 8). The telegraph. Retrieved from http://www.telegraph.co.uk/earth/agriculture/geneticmodification/5770087/GM-cereal-crops-created-to-grow-in-salty-water.html

[2] Honjo, I. (1962). Kouto gakko Rika Seibutu (Textbook of Biology for high school students). Tokyo: Keirinkan.

[3] Darryl, M., & Mary, A. C. N. (2000) Changing attitudes to biotechnology in Japan. Nature Biotechnology, 18, 945-947 doi:10.1038/79425

[4] Kamada, H. (2008). Idensi kumikae gizyutsu no kokuminnteki rikai ni kannsuru tyosa kennkyu (The research on national understanding of genetically engineering technology). Tsukuba: Tsukuba University

[5] Imahori, K., Ohta, J. & Maruyama, K. (1985). Koto gakko Seibutu Kaiteiban (Textbook of biology for high school students: revised edition). Tokyo: Keirinkan.

[6] Motokawa, T. (2006). Koto gakko Seibutu (Textbook of biology for high school students). Tokyo: Keirinkan

[7] Idensi kumikae sakumotu ni kannsuru zyoho teikyo no torikumi to sono kouka ni tuite (The attempt of information provision on genetically engineered crops and this effect). Shiga: The center of agriculture technology promotion.

The Best Way to Move in the Rain

Takuma Inoshita

Faculty of Science, Kyoto University

Abstract: When it is raining and you have no umbrella, I am sure that most of you run in the rain. However, is that really a good idea? If you walk in the rain, the rain falling in front of you does not hit you. However, if you run in the rain, it does hit you. Is it better to run or to walk? This paper presents a way to move in the rain to get wet as little as possible. To propose this method, I found the relation between the quantity of rain impacts and the speed at which one moves in the rain by theoretical calculation and produced graphs illustrating this relation. The shapes of the graphs can be changed based on wind speed. In conclusion, when there are contrary winds or weak winds, you should run as fast as possible. When there are strong winds, you should move at the same speed as the wind.

Key Words: rain, running in the rain, walking, wet

1. Introduction

When it is raining, it seems to be natural for people without an umbrella to run in the rain. However, does running really minimize exposure to the rain? If you walk in the rain, the rain falling in front of you does not hit you. If you run, it does hit you. In other words, you expose yourself to more raindrops when you run in the rain. Which is better, running or walking?

This paper presents the way to move in the rain without an umbrella while getting wet the least and identifies the reason for this phenomenon.

This problem has been considered as the "running in the rain problem." Some have simulated the problem on the computer; others have performed experiments. However, neither formula nor data alone is completely convincing.

In this paper, I used theoretical calculation to find an equation showing the relation between the quantity of rain impacts and the speed at which one moves in the rain. In discussing the meaning of the equation, I make the resolution of this problem easier to understand.

2. **No Wind**

2-1 Methods (no wind)

2.1.1Condition (no wind)

I examined the relation between the quantity of rain impacts and the speed at which one moves with theoretical calculations. The total quantity of rain impacts (Q) is the product of the quantity of rain impacts per unit time (q) and the length of time one is in the rain (t). First, I derived the quantity of rain impacts per unit time. Next, I multiplied it by the time spent in the rain.

First, I set the conditions. I assumed that the rain density of space is uniform, the velocity of all raindrops is fixed and equal and there is no wind. Each physical quantity was named.

L : distance of travel
v : raindrop velocity
s : speed of movement
x : body thickness
y : body height
z : body width
ρ : rain density of space

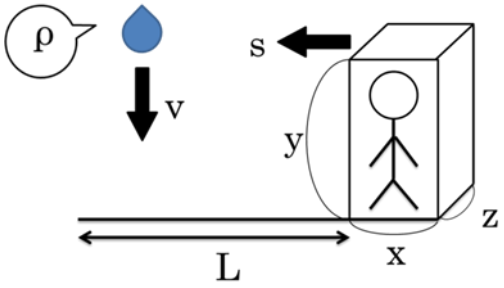


Figure 1: Condition (no wind)

To simplify the calculation, the relative velocity of a raindrop to passerby was defined. I named angles *θ, φ* and the relative velocity *V'* as shown in Figure 2.

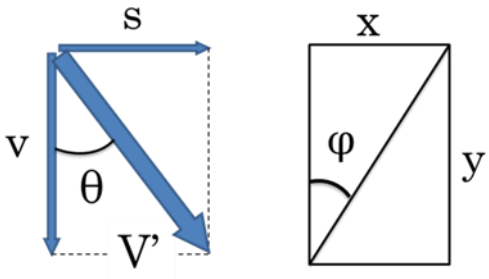


Figure 2: Simplifying the calculation

2.1.2 Calculation (no wind)

First, the quantity of rain impacts per unit time was considered in two dimensions, *x*-*y*. Second, thickness, *z*, was considered in three dimensions. Finally, time was taken into account.

The quantity of impacts per unit time in two dimensions is illustrated by the blue square in Figure 3.

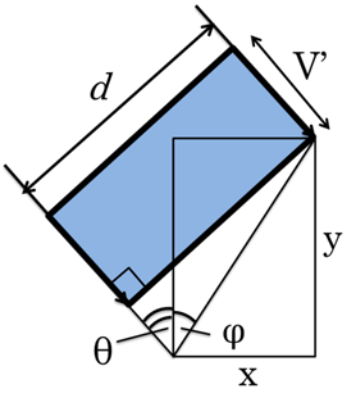


Figure 3: The quantity of rain impacts per unit time in two dimensions

The range in which rain impacts fall is named *d*. The right triangle of θ plus φ degree in Figure 3 is of particular importance. Here, *d* can be determined as follows:

$$d = \sqrt{x^2 + y^2}\, sin(\theta + \varphi)$$
$$= \frac{1}{V'}(vx + sy).$$

Next, considering body width z in three dimensions, the quantity of rain impacts per unit time is represented by the blue box in Figure 4. The quantity of rain impacts per unit time is the product of the volume of the blue box and the rain density of space. It equals the product of the relative velocity, the range in which rain impacts occur, body width and the rain density of space.

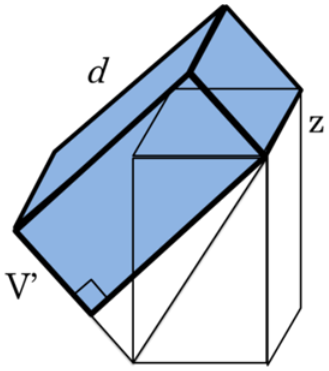


Figure 4: The quantity of rain impacts per unit time in three dimensions

To find the total quantity of rain impacts, time spent in the rain was considered.

$$Q = q \times t$$
$$= V' \times d \times z \times \rho \times t$$
$$= V' \times \frac{1}{V'}(vx + sy) \times z \times \rho \times \frac{L}{s}$$

$$= vxz \times t + yzL$$

This calculation yields the total quantity of rain impacts.

2-2 Results (no wind)

The total quantity of rain impacts was indicated by the sum of a constant term and a term proportional to time ($Q = vxz \times t + yzL$).

The graph in Figure 5 illustrates the relation between the quantity of rain impacts and the speed of movement in the rain.

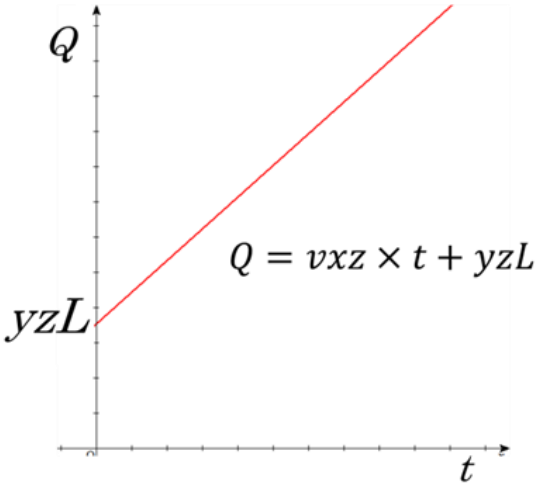


Figure 5: Relation between the quantity of rain impacts and the speed of movement Graph (no wind)

2-3 Discussion (no wind)

The total quantity of rain impacts could be indicated by the sum of a constant term and a term proportional to time ($Q = vxz \times t + yzL$). The constant term, *yzL*, represents the space traversed. The term proportional to time is the product *xzv*, which multiplies the quantity of rain impacts to one's head per unit time by the length of time spent in the rain (Figure 6).

Based on Figures 5 and 6, the faster you run, the shorter the length of time you spend in the rain and the less you get wet.

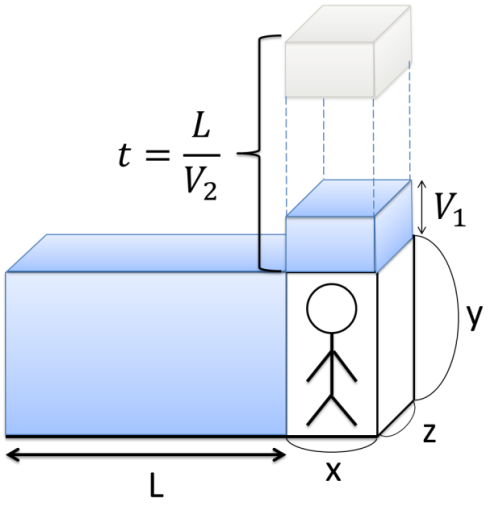


Figure 6: The meaning of the formula

3. Winds Exist

3-1 Methods (winds exist)

3.1.1 Condition (winds exist)

This condition is nearly the same as the no-wind condition, with the added factor of wind speed *w* (Figure 7).

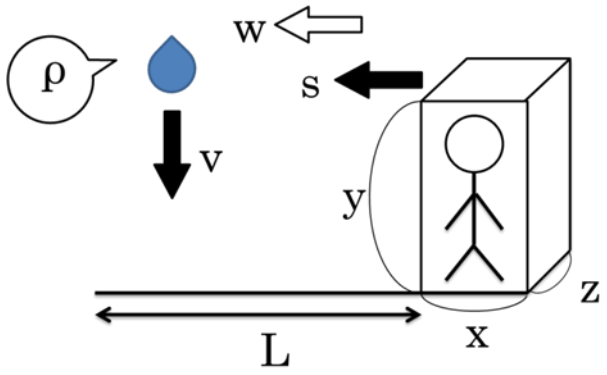


Figure 7: Condition (winds exist)

3.1.2 Calculation (winds exist)

The method of calculation here is nearly the same as in the absence of wind, but requires us to consider two separate cases: (i) when rain hits you from the front, and (ii) when rain hits you from the back.

(i) When rain hits you from the front,

$s - w \geq 0$ so as to $s \geq w$

$$Q = V' \times d \times z \times \rho \times t$$

$$= V' \times \frac{xv + y(s-w)}{V'} \times \rho \times z \times \frac{L}{s}$$

$$= \rho z L \left\{\frac{xv+y(s-w)}{s}\right\}.$$

(ii) When rain hits you from the back,

$s - w < 0$ so as to $s < w$

$$Q = V' \times d \times z \times \rho \times t$$

$$= V' \times \frac{xv + y(w-s)}{V'} \times \rho \times z \times \frac{L}{s}$$

$$= \rho z L \left\{\frac{xv + y(w-s)}{s}\right\}.$$

As explained above,

$$Q = \rho z L \left\{\frac{xv + y|s-w|}{s}\right\}.$$

3-2 Results (winds exist)

The shapes of graphs showing the relation between *s* and *Q* can be changed by wind speed and direction.

When rain hits you from the back, this relationship is simple.

From (ii), when rain hits you from the back,

because $s < w$

$$Q = \rho z L \left\{\frac{xv + y(w-s)}{s}\right\}$$

$$= \rho z L \left(\frac{xv + yw}{s} - y\right).$$

However, when rain hits you from the front, the relationship is complex.

From (i), when rain hits you from the front,

because $s \geq w$

$$Q = \rho z L \left\{\frac{xv + y(s-w)}{s}\right\}$$

$$= \rho z L \left(\frac{xv - yw}{s} + y\right).$$

Here, the shape of the graph depends on the sign of $xv - yw$, as illustrated in the following three cases.

1. $xv - yw > 0$ so as to $w < \frac{xv}{y}$

This condition gives the graph in Figure 8.

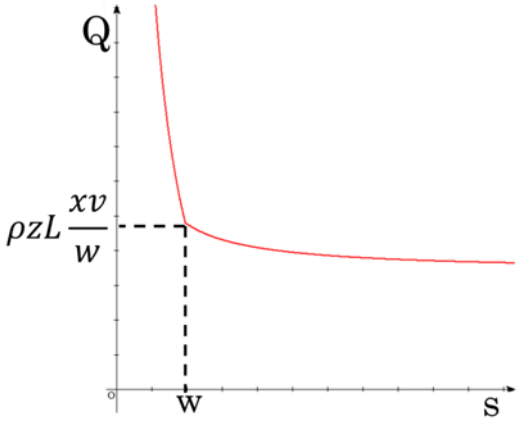


Figure 8: Relation between the quantity of rain impacts and the speed of movement Graph (with wind) of condition 1

2. $xv - yw = 0$ so as to $w = \frac{xv}{y}$

This condition gives the graph in Figure 9.

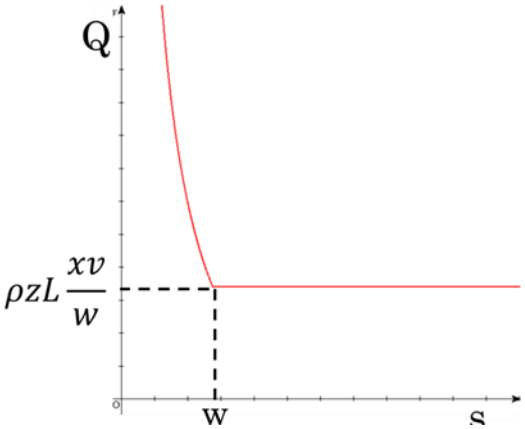


Figure 9: Relation between the quantity of rain impacts and the speed of movement Graph (with wind) of condition 2

3. $xv - yw < 0$ so as to $w > \frac{xv}{y}$

This condition gives the graph in Figure 10.

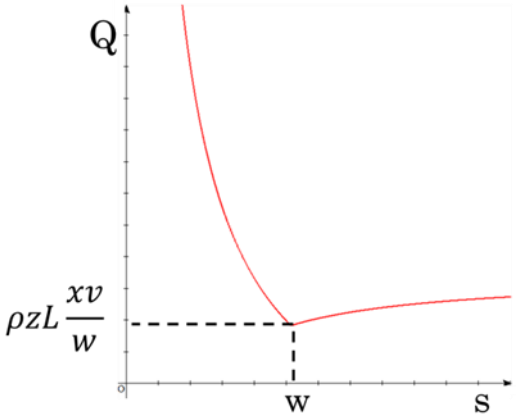


Figure 10: Relation between the quantity of rain impacts and the speed of movement Graph (with wind) of condition 3

3-3 Discussion (winds exist)

Judging from these graphs, when the wind is strong, we should run as fast as the wind blows. In the other cases, we should run as fast as possible.

This section discusses the meaning of $xv - yw$. If we run in the rain at the same speed as the wind, the front of the body does not get wet. However, even if the front of the body does not get wet, the head receives more raindrops and gets wetter, obviating any advantage. Let us now examine the relationship between the quantity of rain hitting the front of the body and that hitting the head of body.

As an example, take the case in which we run as fast as the wind blows *(s=w)* and in which the quantity of rain hitting the front equals that hitting the head.

$$(\text{rain hitting to the head}) = (\text{rain hitting to the front})$$

$$vxz \times t = Lyz$$

$$vxz \times \frac{L}{s} = Lyz$$

$$\frac{vx}{w} = y$$

$$w = \frac{vx}{y}$$

Therefore, $xv - yw$ is like a comparison between the quantity of rain that hits the front and the quantity that hits the head.

4. Conclusions

In conclusion, the best way to keep dry in the rain depends on the speed of the wind.

When there are contrary winds, no wind or weak winds, you should run as fast as possible: the faster you run, the shorter the time you spend in the rain. When there are strong winds, you should move as fast as the wind blows. Only in a case as in section 6 (b) should you run faster than the wind blows.

Regarding the meaning of formulas and terms, the first term in each equation showing a total amount of rain represents the amount received horizontally (on a vertical surface) and the second term represents the amount received vertically (on a horizontal surface). The key term affecting the shapes of the graphs, xv/y, results from a comparison of the horizontal and vertical amounts.

Based on this research, we can choose the best speed at which to move to get the least wet.

Using these formulas, in the future, I would like to attempt to find the best posture to minimize rain exposure, e.g., standing straight or stooping.

5. References

[1] Herb Bailey (2002) *On Running in the Rain.* The College Mathematics Journal (pp. 88-92)

[2] Mark J. Volkmann (1993) *To Walk or Run in the Rain: A Geometric Solution.* School science and Mathematics (pp. 217-220)

[3] T. Kroetz (2009) *The "running in the rain" problem revisited: an analytical and numerical approach.* Revista Brasileira de Ensino de fisica

Decreasing Voter Turnout and the Declining Birthrate

Tenshin Sugiyama

Faculty of Education

Abstract: Japan is in a structurally difficult situation in terms of the declining birthrate, which is a serious problem. Additionally, voter turnout among young people is decreasing. This study focused on the relationship between decreasing voter turnout and the declining birthrate. The correlation between these events is that both are produced by a distrust of politics.

Key Words: voter turnout, decrease in the birthrate, silver democracy, distrust of politics

1. Introduction

Japan can be considered to be in a structurally difficult situation. Japan has serious problems in many areas, such as increases in unemployment and decreases in the birthrate, which is a particularly serious problem. Therefore, Japan requires structural reform to address this issue. Furthermore, voter turnout among young people, who should determine their own future, is declining [1][2]. Political scientists say that "silver democracy" [3] has a negative effect on the voter turnout of young people. Silver democracy (also called "gerontocracy") is the concept that older people have a greater effect on politics as the number of young people decreases. Under silver democracy, Japanese politics follows a pattern in which decreasing birthrates and increasing longevity lead young people to observe that their interests are not reflected in politics. Politicians make laws that are favored by older people in an attempt to win votes and elections. Therefore, young people lose interest in politics, and many young people stop voting in elections [4].

In 2007, Japan had 15,033,000 young people (20-29 years old) and 27,464,000 older people (over 65 years old) [5]. Voter turnout among young people was approximately 30-50 %, whereas voter turnout among older people was 70-85 % [6]. Clearly, older people have political power, but the validity of the hypothesis of silver democracy has not been tested.

In light of the above discussion, this paper tests the relationship between declining voter turnout and decreases in the birthrate.

2. Method

This paper examines the relationship between factors that govern the voting turnout of young people and factors that govern the Japanese birthrate through an international and temporal comparison.

3. Results

Three studies are described in this section.

A. The correlation between the Japanese total fertility rate and the voting turnout of people in their twenties in the House of Representatives election is shown in Figure 1:

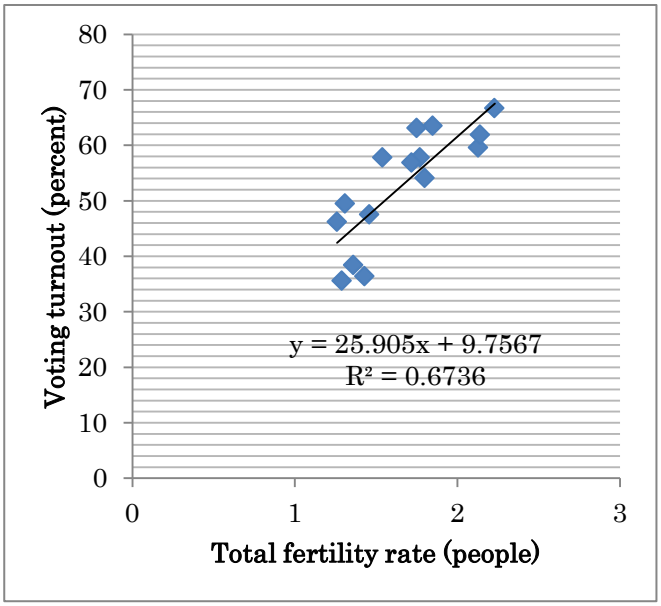


Figure 1: correlation between the Japanese total fertility rate and the voting turnout of people in their twenties in the House of Representatives election

The data on voting turnout among people in their twenties are from the 31st to the 45th elections of the House of Representatives [7]. The total fertility rates are for election years [8]. As calculated by Microsoft Excel 2010, the correlation coefficient is 0.6736, indicating some correlation between the two indexes.

B. I asked the following questions to 24 first-year students in the Faculty of Education.

Table 1: Questionnaire

No.1 Will you vote in the election?		
a. certainly	b. if it is convenient	c. I will not
No.2 Which group has more political power?		
a. young people	b. older people	c. neither group

No.3 Do you think that your vote reflects the intentions of the younger generation?		
a. yes	b. no	c. there is no meaning in one vote
No.4 For respondents who chose b or c for No. 3: Did you choose your answer (b or c) because of the low birthrate and high longevity in Japan?		
a. very much	b. somewhat	c. completely unrelated

Table 2: Questionnaire results

Table 1			
	a	b	c
No.1	14	10	0
No.2	6	6	12
No.3	12	8	4
No.4	1	4	7

Table 2 suggests that a few respondents felt that the political weakness of young people is due to the low birthrate and high longevity.

C. The relationship between total fertility rates [9] and voting turnouts [10] for 15 randomly selected countries is shown below:

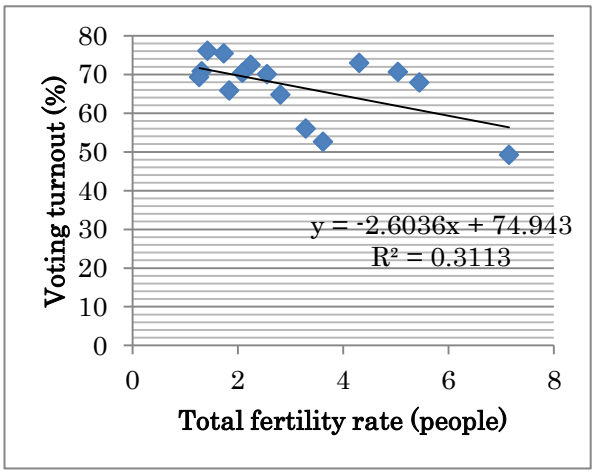


Figure 2: For voting turnout, I used the most recent information from IDEA (International Institute for Democracy and Electoral Assistance)

As calculated by Microsoft Excel 2010, the correlation coefficient is 0.3113. Although the method of calculation varied by country, there appears to be a very weak correlation between the two indexes. Thus, the total fertility rate and voter turnout do not always change simultaneously. In short, there is no causal relation between these indexes. If there were such a correlation, these indexes would always change together.

4. Discussion

Figure 1 suggests that there is a correlation between the total fertility rate and voter turnout among young people. However, the questionnaire and Figure 2 indicate that the correlation is an apparent one. An apparent correlation is present when two indexes show a correlation with one another because they affect one another, not because there is a direct causal relationship between them.

Therefore, though older people have several political advantages, this fact does not have the effect on young people and politicians that silver democracy suggests.

The above discussion suggests that another factor influences declining voter turnout and decreases in the birthrate. Kobayashi [11] uses 8 models to present voter behavior: regional peculiarities, social attributes, party support, point-at-issue attitudes, political reliance, performance evaluation, candidate evaluation, and election campaigns. Many studies have examined the model of political reliance, and most of these studies find that political distrust makes people feel politically powerless. Political efficacy plays an important role in this process. Political efficacy is the feeling that one has an influence on a political process. Although the concept of silver democracy also suggests political efficacy, it incorrectly assumes that an aging society causes young people to losetheir political efficacy.

As Shindo [12] says, when politicians pay attention only to election campaigns, people think that politicians do not consider public opinion, so people cannot have political efficacy. Hence, people who consider themselves politically powerless do not vote in elections because they cannot change anything. The election opinion polls, researched by Shiga prefecture [13] support this opinion. In all investigations for the past ten years, 70 % of respondents chose "distrust of politics" as a reason for declining voter turnout in various elections.

In summary, the above discussion argued that the political efficacy of young people is reduced not by low birthrate and longevity but by political distrust.

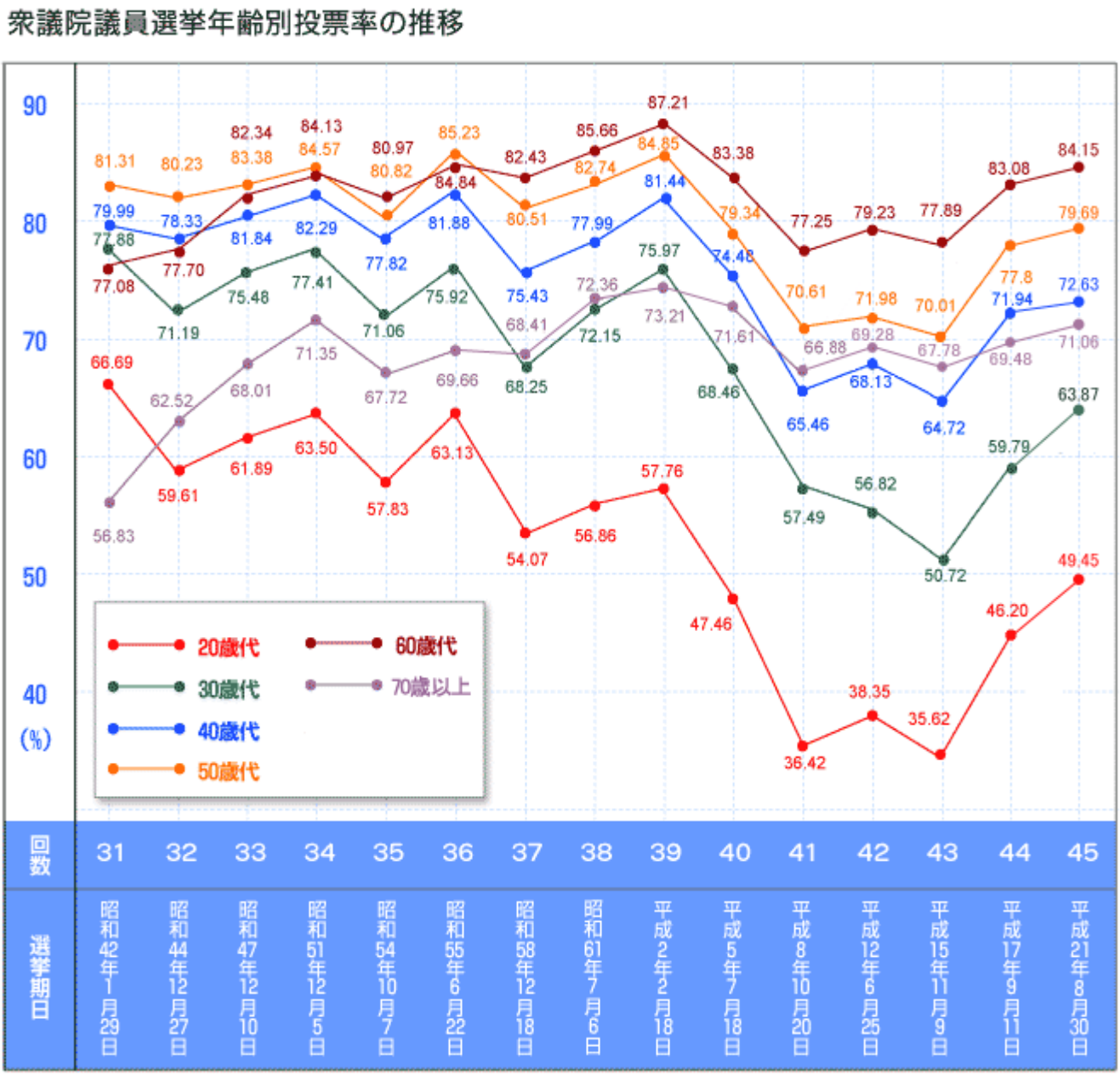
Many studies have examined the low total fertility rate in Japan. One study by Hakuhodo [14] shows that people refrain from having children due to economic anxiety and the shortage of institutions like nursery schools. Seike [15] says that childrearing is a social risk. By nature, society should take over that risk. However, many respondents stated that government should strengthen aid for childcare. When people distrust the government and think that the childrearing environment will not improve, they refrain from having children. In summary, people want the government to support childrearing, but the government does not respond. People begin to distrust the government and, ultimately, refrain from having children. Hence, it can be said that political distrust is an indirect cause of the low Japanese birthrate.

5. Conclusions

The concept of silver democracy argues that low birthrate and high longevity lead to a decline in young voter turnout. However, there is an apparent correlation between these factors; both are caused by political distrust.

This paper focused on only a few of the many suggested reasons for the decline in voter turnout among young people and the relationship between low birthrate and longevity. I would like to investigate these factors further in future research.

6. Appendix [1]



7. References

[1] The bright election promotion committee retrieved from: http://www.akaruisenkyo.or.jp/070various/071various/377 See Appendix for details.

[2] Masaru, Miyano (2009) Fundamental study of elections.

[3] Ryohei, takahasi. Issei,Oguro. Shigeyuki, Siro. (2010) What is generation gap?

[3] JCER retrieved from: http://www.jcer.or.jp/report/econ100/pdf/econ100bangai20110713data.pdf

[4] Ministry of Internal Affairs and Communications retrieved from: http://www.stat.go.jp/data/jinsui/2007np/index.htm

[5] Same as 1. See Appendix for details.

[6] Same as 1. See Appendix for details.

[7] Ministry of Health, Labour and Welfare retrieved from: http://www.mhlw.go.jp/toukei/saikin/hw/jinkou/suikei09/index.html

[8] UN retrieved from: http://www.un.org/esa/population/publications/wpp2008/wpp2008_text_tables.pdf

[9] IDEA retrieved from: http://www.idea.int/vt/

[10] Yosiaki, Kobayasi. (2000) Voting and election movement.

[11] Muneyuki, Sindo (2000) Politician only with an election, people do not even elect.

[12] Shiga prefecture retrieved from: http://www.pref.shiga.jp/senkyo/isikityousa_list/isikityousa_anke_list.html

[13] Hakuhodo retrieved from: http://www.hakuhodo.co.jp/pdf/2002/20020215.pdf

[14] Atusi, Seike. Masahiko, Iwamura. (2002) The point of argument of an aid for childcare.

[15] Atusi, Seike. Masahiko, Iwamura. (2002) The point of argument of an aid for childcare.

A New Method of Fluid Visualization with the Line Sensor Camera

Tomoya Tanaka

Faculty of Engineering, Kyoto University

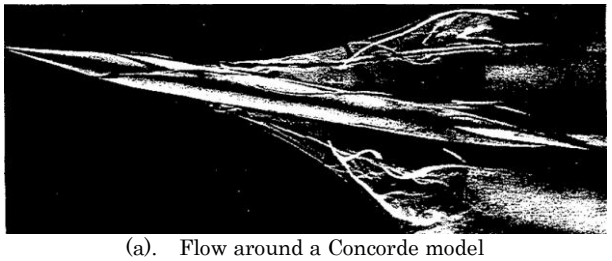
Abstract: This experiment presents a new approach to visualizing fluid with a line sensor camera. Applying principles similar to those used by a scanner, the line sensor recorded the diffusion of a liquid in a second liquid. Until now, researchers have relied on traditional cameras or video to visualize flows of different liquids or gases. Conventional methods show fluid as continuous surface data, but our method succeeded in representing the phenomenon of diffusion in one picture with variations over time. Ultra-high-resolution imaging enables us to show the microstructure of flows in more detail compared to conventional graphics and videos. The image quality is approximately one order of magnitude higher than that of High-Definition images. Combining this process with common techniques represents a major advancement in hydrodynamics imaging.

Key Words: visualization, line sensor, diffusion, hydrodynamics

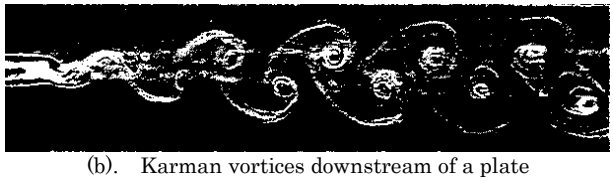
1. Introduction

With advancements in hydrodynamics and aerodynamics, numerous methods have been developed to visualize the shapes and detailed variations of fluids. A previous study by Werlé classified visualization methods according to the nature of elements or processes (Werlé, 1973 [1]). These images were recorded by a still camera or a video camera as a sequence of area data over certain time intervals. Figures 1a and b are examples of the visualized flow of wind, from experiments conducted in a wind tunnel using colored emissions as a tracer. In that procedure, to investigate change over time it was necessary to compare multiple images, generate cyclic tracers, or use short-term exposures and regard the results as sequential displacements. Figures 1c and d show a pseudo-fluid with intermittent hydrogen bubbles and air bubbles in a brief exposure.

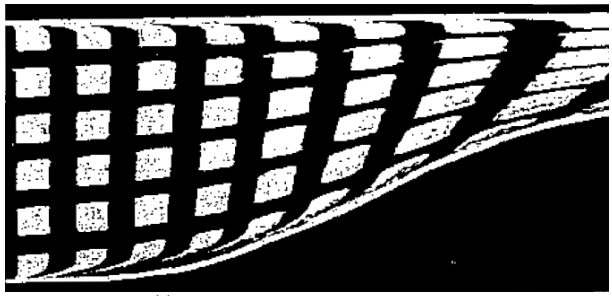
Is it therefore impossible to obtain both consecutive time-scale variation and space-scale variation in one picture without degrading the image quality? This question motivates our experiment. We used a line sensor camera in an attempt to visualize variations from a particular position, and applying the principle of the scanner, took sample images of fluid diffusion. There are few papers on experimental visualization, especially the phenomenon of diffusion. The method described in this paper is a novel approach.



(a). Flow around a Concorde model



(b). Karman vortices downstream of a plate



(c). Lines of hydrogen bubbles

(d). Flow of air bubbles with short exposure

Figures 1: visualized flow of wind and pseudo-fluid with intermittent hydrogen bubbles and air bubbles in a brief exposure ([1])

2. Experiments

2-1. Experimental Set-up

(1) Water Sheath

The sheath-type water tank has two layers. The internal section is made of rigid PVC, and the external section is a thin glass plate. The interior dimensions of the tank are 5 mm thick, 260 mm wide, and 185 mm high. The depth of water was adjusted to approximately 150 mm.

(2) Line Sensor Camera

A line sensor camera with 7400 pixels per line was used as our imaging system. Compared to high-definition (HD) video images, which have 1080 dots per line, line sensor cameras have superior image quality, with nearly 640 pixels per inch (PPI). The scales behind the sheath are 82.7 mm (3.26 inches), and 50 mm in actuality. These are not shown in Figures 3b, c, and d, so we have standardized the magnification to 1.65. The image capture time interval (time required to record one line) is 2 milliseconds.

(3) Set-up

The tank was secured vertically with metal fittings, and a white paper with the described scale on it was set behind the transparent tank. This scale can be seen in the picture as black lines. The line sensor camera was separated from the sheath at a distance of approximately 350 mm. Two linear LED light sources were also placed on both sides of the camera, allowing us to use reflected light.

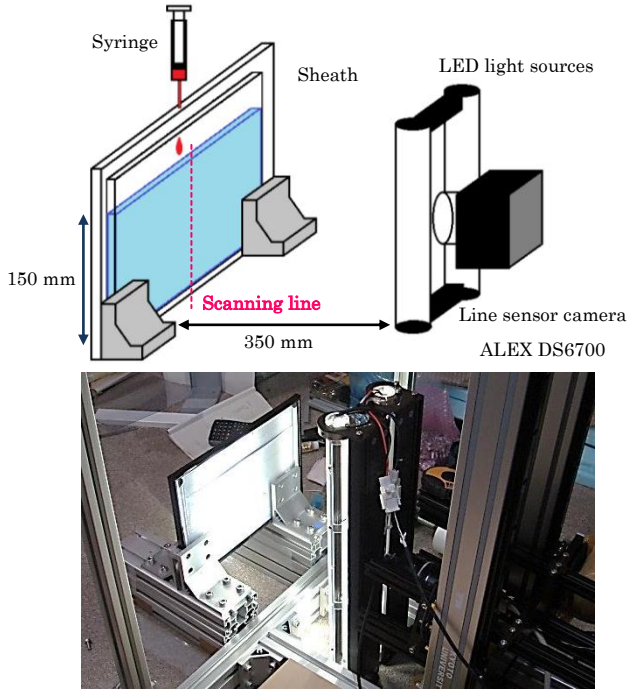


Figure 2: Experimental imaging equipment

2-2. Procedure

The samples of this experiment were saline solutions of two different densities: 1% and 10%. These solutions also included commercial powdered food colorant containing 12% Food Red No. 102 (New Coccine) and 88% white dextrin.

First, the sheath was filled with fresh water and placed in the apparatus as shown in Figure 2.

Second, the centers of the sheath and the drip point were focused by checking an input-signal monitor. In this way, we ensured that the scanning line of the line sensor camera and the direction of the diffusion were aligned.

Finally, a drop of the colored saline was administered with a syringe after the recording had begun. This process was repeated five times for each sample.

2-3. Time-scale Image as Predicted

In this experiment, the scanning line was fixed and the change of diffusion at that line was recorded every 2 milliseconds as a thin picture. By arranging and accumulating these pictures, we can capture an image whose horizontal axis stands for time-scale variation and whose vertical axis represents space-scale variation on the scanning line. This concept is explained in Figure 3.

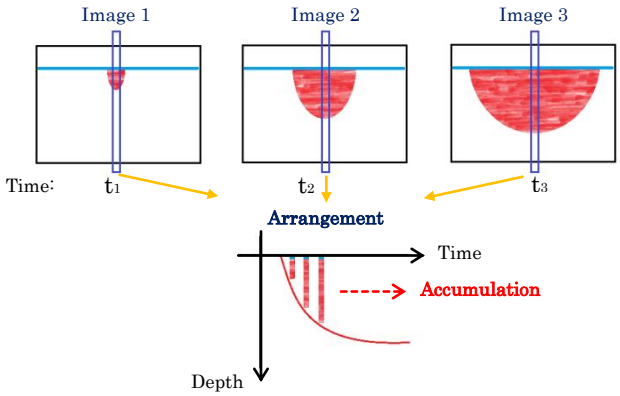


Figure 3: Concept of imaging with the line sensor camera

3. Results

3-1. Time-scale and Space-scale Imaging

Figures 3b and c present examples of our results with 1 % and 10 % saline solution, at 1/25 scale. The rough shape of the red area coincides with our expectation articulated in Figure 3. Here, changes in depth can be clearly recognized. The ultra high-resolution imaging brings these details to light and makes it possible to observe localized changes in density from a range of marbled red tones.

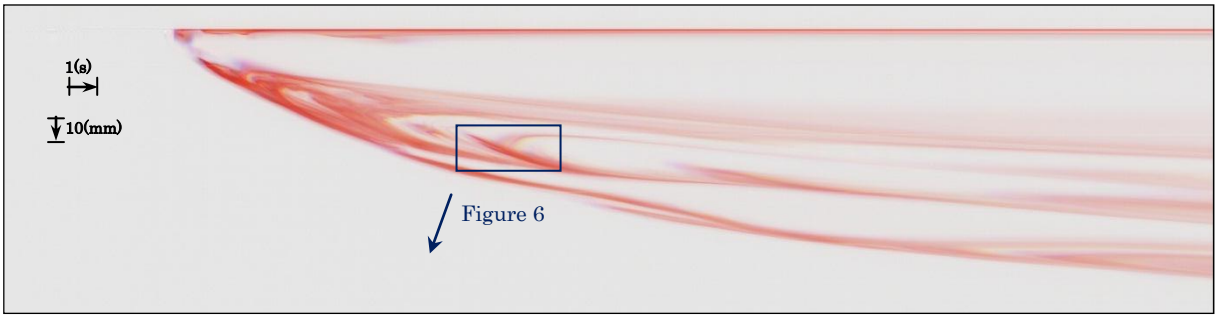


Figure 4: Diffusion of 1% saline solution varying over time

Figure 5: Diffusion of 10% saline solution varying over time

Figure 6: Marbled patterns of 1% saline solution

3-2. Imaging in Microstructure

Figure 6 depicts the enclosed area with a blue line in Figure 4. Even at this magnification, the edge of the boundary layer is distinct and smooth, owing to the ultra high resolution and brief recording time.

"Marbled" patterns mentioned above are separated more minutely. As seen Figure 6, red lines that were once detached from each other unite with the passage of time. The thickness of the red color also changes over time. Such a complex phenomenon, which is difficult to distinguish with the naked eye, cannot be described with "conventional" imaging methods. Based solely on Figure 6, we can obtain various kinds of information, such as the displacement in the perpendicular downward direction and the vertical distribution of saline solution.

3-3. Transformation to Numeric Data

The location and the velocity of the edge can be quantified based on the images in Figure 4 and c, as represented by Figures 3e and f. In this analysis, we focus on these initial sections because the changes seen in these sections are rapid and the boundaries are vivid. Each point in the graph represents every 50th pixel in the time dimension, sampled at an interval of 2 ms; in short, it shows changes per 0.1 seconds. It is a somewhat rough numeric conversion compared to the time interval used by the line sensor camera. The data from the 1% solution in Figure 7 is not obtained due to a lack of tracer.

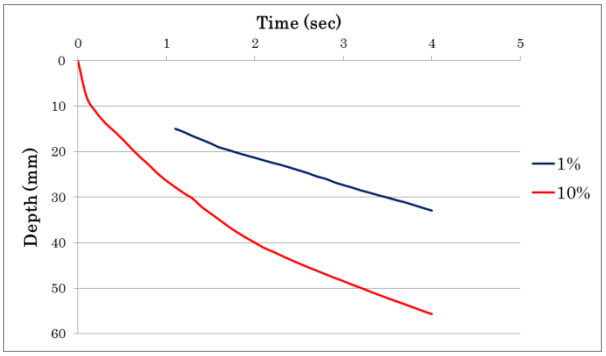


Figure 7. Variation of the locations at the initial section

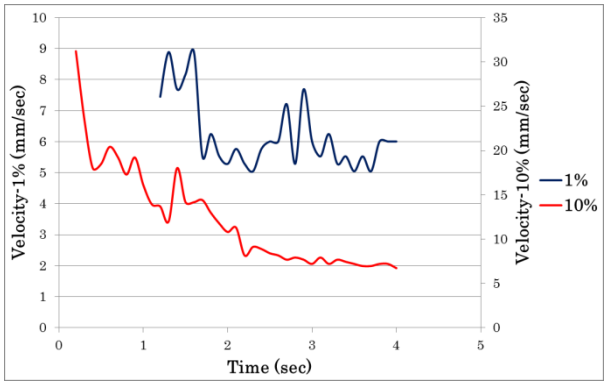


Figure 8. Variation of the velocity at the initial section

4. Discussion

4-1. Advantages of the Images

As shown in Figures 3b, c, and d, our proposed method provides innovative images compared to current methods. These images include data about both time-scale and space-scale change with ultra high-definition quality and are suitable for analysis. From only one picture, we can deduce the location, velocity, and distribution of the tracer and its parameters. Moreover, these measures can be obtained quickly.

Other devices, such as high-speed cameras, have been used to produce similar results, but at a high cost and with the need to produce and store enormous amounts of unnecessary data. Additionally, it is possible to improve the performance of the line sensor camera in ways that are not possible with traditional imaging systems. In this case, PPI can be reduced to improve focus. In theory, it is possible to raise the PPI to nearly 2000. The time interval can be similarly adjusted simply by reducing the exposure time.

4-2. Analysis of Diffusion

Figures 3e and f show that the 10% saline solution diffuses more quickly than the 1%. This is consistent with Fick's law, which argues that the speed of diffusion is proportional to the gradient of density.

However, the velocities in Figure 8 continue to increase and decrease, in contrast to the theory which predicts a monotonic deceleration in the speed of diffusion. There are many possible reasons for this: friction between the saline solution and water, occurrence of nonturbulent flow, and the wall effect among them. This paper focuses on the marbled patterns as shown in Figure 6.

From our observation, the marbled patterns indicate pressure due to difference in density. Assuming that the concentration of red color corresponds to a condensation of saline solution, the margin of the red line means that the following line does not overtake the edge, and it produces a force opposing the direction of movement illustrated in Figure 9 as yellow arrows, after which they are confluent. This cycle would change the velocities of these regions. This method enables us to measure quantitative changes in marble patterns.

Figure 9. Mechanism of marble patterns

4-3. Future Directions for Better Imaging

This experiment has brought several problems to light. As shown in Figure 10, the saline solution casts a shadow which makes the boundary indistinct. Altering the method of lighting from reflected to transmitted light will help correct this flaw. Of course, this requires us to change the exposure time and capture intervals appropriately.

The direction of the scanning line also provides room for improvement. If the scanning direction is changed from vertical to horizontal, a very different image of a new aspect of fluid diffusion will appear. Combining the vertical image with the horizontal image may allow new discoveries to be made.

4-4. Limitations

The greatest limitation is the gap in the scanning line. In a case like that presented in Figure 11, the center of diffusion does not agree with the scanning line, which will result in a lack of data, as in Figure 12. Because the scanning line is fixed, it is an unavoidable problem. This makes the line scanning method most suitable for studies of phenomena whose central axis does not move materially.

In addition, there is the problem of imaging depth. In this case, the area of diffusion is limited to 5mm in depth. To record deeper phenomena, the resolution must be reduced in order to maintain adequate focus.

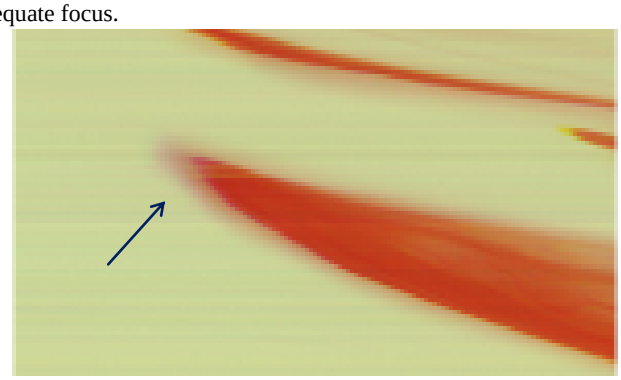


Figure 10. Shadow of the saline solution

4-5. Application

As shown in Figures 7 and Figure 8, a numerical analysis of diffusion is possible from these images. Diffusion coefficients can be obtained experimentally by gathering data using this method.

Our method is easily executed and extended to various fields beyond diffusion. As pilot studies, the movement of a small piece of paper floating on the waves and the cyclic change of the flow of water propelled by a screw were visualized. The results are shown in Figures 13 and Figure 14.

This method can also be used to analyze the change in time variation, especially in cyclic phenomena. From the point of view of resolution, phenomena that can be viewed in a thin layer are optimal. Moreover, our method is applicable to other spheres such as chemistry, thermal engineering, and so on.

For example, photochromic methods would benefit from the high-speed and high-definition image (Barachevskii et al., 1983 [2]), and the continuous time-scale imaging brings a fresh point of view to research on the visualization of thermo-hydrodynamic phenomena (Iida et al., 1996 [3]). It would also be effective for observations of the variation of pH using a colorimetric method.

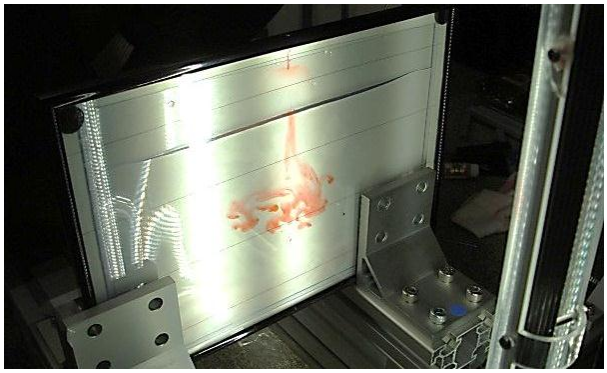


Figure 11. Scanning of bias diffusion

Figure 12. Lack of tracer due to bias diffusion

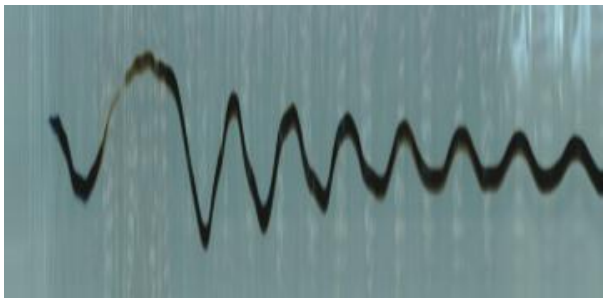


Figure 13. Paper strip drifting on the waves

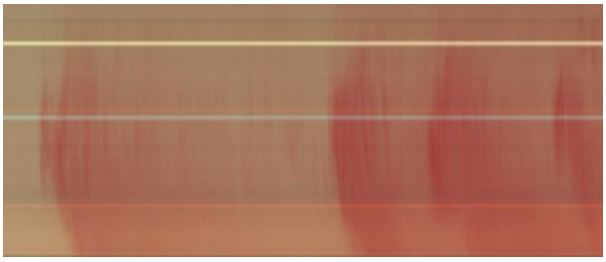


Figure 14. Cyclic fluid displacement by a screw

5. Conclusions

Our method enables scientists to visualize time-scale and space-scale changes in one picture. The images are of high-definition and provide much novel information. For example, the location, the velocity, and the density distribution can be recognized. The ultra high-resolution images show slight changes in diffusion vividly and can be used to analyze microstructural phenomena.

Time-scale and space-scale visualization can be applied to a wide range of experimental fields. From this novel viewpoint, new facts or theories may emerge, and new indicators or parameters such as our “marbled patterns” might be found.

Our imaging project has just begun and has inestimable potential. There are many precedents for time-scale and space-scale imaging, and this experimental method could be the answer to these needs. Combining our process with common techniques would introduce a new sphere of techniques in hydrodynamics.

6. Acknowledgements

This experiment was conducted as part of the pocket seminar, “Advanced Imaging Technology” in Kyoto University.

The author would like to express thanks to Dr. A. Ide-Ektessabi and the students in the Advanced Imaging Laboratory, Graduate School of Engineering, Kyoto University for their support and invaluable help.

7. References

[1] Werié, H. (1973). *Hydrodynamic Flow Visualization*. ONERA/France: Annual Review. Fluid Mechanics. 1973. 5: 361-386.

[2] Barachevskii, A. V. et al. (1983). *Photochromic Method Visualizing Hydrodynamic Flows*. Moscow: 720-722. 0021-8944/84/2505-0720$08.50: Plenum Publishing Corporation.

[3] Iida, T. (1996). *Visualization Study on the Thermo-hydrodynamic Phenomena Induced by Pulsative Heating in He II by the use of a Laser Holographic Interferometer*. Tsukuba/Japan: Cryogenics. 36: 943-949: 0011-2275/96/$15.00 : Elsevier Science.

[4] Housawa, M. (1996). *Kakusan to Idougenshou [Diffusion and Migration Phenomena]*. Tokyo: Baifukan.

[5] Kondo, Z. (2010). *Furie Kaiseki to Henbibun Houteisiki [Fourier Analysis and Partial Differential Equations]*. Tokyo: Baifukan

Using the Ruby Program to Find the Best Menu Based on Price or Nutritional Value

Hori Yoshihiro

Faculty of Engineering, Kyoto University

Abstract: Maintaining a diet of nutritious foods should be a priority. In reality, sometimes it is difficult to maintain a healthy diet, especially when in financial difficulty. This paper sought to find nutritious and inexpensive menus available in the student union refectory and to develop a recommendation system that helps students to maintain a healthy diet. The cost and nutritious baseline of the menus in "Cafeteria Rune", which consisted of a main dish, a side dish, and soup, were evaluated. The optimal combinations of dishes were determined with a Ruby script. The best menu differs in each person's opinion; therefore, the program was written to be flexible enough to find the best menu while considering personal requests. For me, I found that sabani and renconfry was the best combination.

Key Words: nutritious menu, inexpensive menu, Ruby program, recommendation

1. Introduction

The proverbial saying "an apple a day keeps the doctor away" shows the importance of maintaining a healthy diet. Although it is desirable for everyone to have a healthy diet, the process can be difficult. Spending less money for food is one of the easiest ways for university students to save money. If too little money is spent on food, however, the student may experience poor physical health or become lazy towards schoolwork or extracurricular activities.

A healthy diet is achieved by consuming an appropriate amount of meats, vegetables, and rice or bread. Meats are sources of protein, which builds up the body; vegetables are sources of vitamins and minerals, which maintain the body; and rice or bread are sources of carbohydrates, which provide energy. Each meal consumed should provide a balance of all of these nutrients.

This paper aims to find nutritious and inexpensive menus in the student union refectory by developing a computer program that can provide effective recommendations to help students keep a healthy diet with less money. For the initial trial, the Ruby program was attempted at Cafeteria Renais, where many Kyoto University students have their meals.

2. Methods

2.1. Method Overview

The cafeteria menus were first generated by considering all possible combinations of main dishes, side dishes and soups in Cafeteria Runais". The generated menus were evaluated according to their nutritional values.

(1) Data Sampling

The data of the dishes were obtained at "Cafeteria Renais" on October 21st, 2011. For the purpose of calculating the nutritional values of the menus, red points, green points, and yellow points, along with the prices of the main dishes, side dishes and soups were recorded.

(2) Nutritional Criterion

A color is assigned to represent each nutritional category for the foods in the student refectory. "Red" represents meat, fish, eggs, beans and dairy products, all of which contain proteins that help to build the body. "Green" represents vegetables, fruits, mushrooms and seaweeds, which contain minerals and vitamins. "Yellow" represents grains, oil, and sugar, which are converted into energy. Each meal should have 2 red points, 1 green point, and 4 to 7 yellow points; and 1 point is equal to 80 kcals. In this paper, the total number of red and green points as well as the total number of calories was evaluated.

2.2. Calculation

To generate and evaluate the menus, the Ruby program was used. For the calculation, the following variables and formulae were used.

(1)Variables and Their Descriptions

sumR: sum of "Red points" in the main dish, side dish and soup

sumG: sum of "Green points" in the main dish, side dish and soup

sumY: sum of "Yellow points" in the main dish, side dish and soup

sumA: sumR + sumG + sumY

sumP: sum of price

(2)Formulae and their definitions

Formula 1-1-1: Definition of red_P

```
red_P = sumR/2
 if red_P > 1
   red_P = 1.0
```

Formula 1-1-2: Definition of green_P

```
green_P = sumG/1
 if green_P >1
   green_P = 1.0
```

Formula 1-2: Definition of calorie_P

calorie_P = sumA/6
if calorie_P > 1
calorie_P = 1.0

Formula 1-1: Definition of nutritive_P

nutritive_P = red_P + green_P

Formula 1: total_P (total point of the menu)

total_P = nutritive_P + calorie_P

Formula 0: e_value (whole evaluation of the menu)

e_value = total_P/sumP

The “total_P” was the total number of points of the menu, “nutritive_P” was the number of nutritive points and “calorie_P” was the total number of calories. The nutritive points were the sum of “Red_P” and “Green_P”.

The evaluation was conducted by achievement revels of each color and calorie. Achievement revel was basically calculated as (the sum of each color’s points) / (required points for each colors). For instance, the achievement level for the red points was calculated as (summation of “Red points”)/2, and values above 1 was not considered. The achievement level for the green points was calculated as (summation of “Green points”)/1, and values above 1 were not considered. The achievement level for the total calories was calculated as (summation of “Red points” + summation of “Green points” + summation of “Yellow points”)/6, and values above 1 were not counted. By discarding the points exceeds 1, unbalanced menus were expelled.

In the program, the total number of calories was evaluated instead of the number of yellow points. Because rice was not considered in this program, the total number of yellow points could be easily affected by adding different amounts of rice. Therefore, this program assumed that the default size of rice was small and that the menu without rice should be 480 kcal. This enabled the students to easily adjust the total calories of their meal just by choosing a different size of rice. The entire Ruby program was based on this method and is shown below.

2.3. Ruby Program

```
# BestMenuFinder
# program begin


# data
maindish = [
["toripon",2.1,0.2,1.8,258],
["hamburg",1.4,1.3,3.7,252],
["tonkatsu",0.9,0.1,6.4,294],
["shirofry",0.6,0.2,4.3,294],
["sasamifry",1.2,0.1,5.5,252],
["lechicken",0.5,0.1,2.5,168],
["wakadori",0.8,0.1,1.7,168],
["imotaki",1.6,0.8,0.8,168],
["SGYKsalda",1.4,0.1,1,252],
["keichan",1.9,0.6,1.8,252],
["kakifry",0.3,0.1,4.3,210],
["sanmafry",3.7,0,1.5,168],
["sanmayaki",3.7,0.1,0.0,168],
["sabani",3.7,0.1,0.8,168],
["------",0.0,0.0,0.0,0]
]

sidedish = [
["renkonfry",0.0,0.7,2.4,105],
["yokosuka",0.6,0.0,3.4,105],
["harumaki",0.0,0.1,1.4,52],
["hatahata",0.6,0.0,0.4,136],
["antouhu",0.9,0.0,0.9,84],
["tetsuae",0.6,0.2,0.1,84],
["morisou",0.3,0.2,0.3,84],
["torireba",0.8,0.0,0.5,105],
["hijikini",0.1,0.1,0.2,63],
["okura",0.0,0.2,0.2,63],
["kinpira",0.0,0.3,0.5,63],
["unohana",0.3,0.0,0.3,63],
["wakatsuna",0.3,0.1,0.3,105],
["touhu",0.7,0.1,0.2,84],
["onsenegg",0.9,0.0,0.0,42],
["hourenso",0.0,0.2,0.0,63],
["komatsuna",0.0,0.1,0.1,63],
["------",0.0,0.0,0.0,0]
]

soup = [
["imonijiru",0.4,0.5,0.5,105],
["misosoup",0.0,0.0,0.2,31],
["------",0.0,0.0,0.0,0],
]


# list generator
def listgen(maindish,sidedish,soup)
  list = Array.new
  i = 0
  j = 0
  k = 0
  while i < maindish.length
    while j < sidedish.length
      while k < soup.length
        list << menugen(i,j,k,maindish,sidedish,soup)
        k +=1
      end
      k = 0
      j += 1
    end
  j = 0
  i +=1
  end
  return list
end
```

```
    # menu generator
    def menugen(i,j,k,maindish,sidedish,soup)
      menu = Array.new
      # sum of each elements(red,green,yellow,value)
      sumR = maindish[i][1] + sidedish[j][1] + soup[k][1]
      sumG = maindish[i][2] + sidedish[j][2] + soup[k][2]
      sumY = maindish[i][3] + sidedish[j][3] + soup[k][3]
      sumP = maindish[i][4] + sidedish[j][4] + soup[k][4]
      sumA = sumR + sumG + sumY
      # nutritive evaluation
      red_P = sumR/2 # 160kcal
      if red_P > 1
        red_P = 1.0
      end
      green_P = sumG/1 # 80kcal
      if green_P >1
        green_P = 1.0
      end
      nutritive_P = red_P + green_P
      # calorie evaluation
      calorie_P = sumA/6
      if calorie_P > 1
        calorie_P = 1.0
      end
      # whole evaluation
      if sumP == 0
        total_P = 0
        else
          total_P = nutritive_P + calorie_P
      e_value = total_P / sumP
      end
      # output
      menu                                                                    =
[maindish[i][0],sidedish[j][0],soup[k][0],sumR,sumG,sumY,sumP,
e_value,total_P,nutritive_P,calorie_P]
      return menu
    end


    # sorting
    def sort(list,i)
      list.sort{|a,b| (a[i]<=>b[i])}
    end


    # scope (price)
    def scope(list,i)
      p "lower threshold"
      bottom = gets.to_f
      p "upper threshold"
      top = gets.to_f
      return list.select{|x| bottom <= x[i] && x[i] <= top}
    end

    # main structure
    rawlist = listgen(maindish,sidedish,soup)
    # mode selection
    p "mode selecion"
    p "1:price driven,2:nutrition driven,3:total point driven"
    mode = gets.to_i
    case mode
      when mode = 1
        list = sort(rawlist,6)
        p "type the budget for your meal"
        list = scope(list,6)
        output = sort(list,7)
      when mode = 2
        list = sort(rawlist,9)
        p "type nutiritive point: min(0) to max(2)"
        list = scope(list,9)
        output = sort(list,7)
      when mode = 3
        list = sort(rawlist,8)
        p "type total point: min(0) to max(3)"
        list = scope(list,8)
        output = sort(list,7)
      else
        output = ["invalid input"]
    end
    # output
    if output == [["------", "------", "------", 0.0, 0.0, 0.0, 0, nil, 0, 0.0,
0.0]]
      p "did not match any menus"
    else
      i = 0
      while i < output.length
      p output[i]
      i += 1
      end
    end
    # program end
```

In the data section, the data of the dish were shown in the following format: [Name, Red points, Green points, Yellow points, Price].

The optimal menu with the highest e_value (EV) should fall within a certain price range, nutritive_P, and total_P in this program. The upper threshold (UT) and lower threshold (LT) defined the budget range, the range of nutritive_P or the range of total_P. The price-driven mode gave the best menu within a certain price range. The nutrition-driven mode gave the best menu within a certain range of nutritive_P. The total points-driven mode gave the best menu within a certain range of total_P. Generally speaking, the price-driven mode was for use by an individual who lacks money, the nutrition-driven mode was for use by an individual with an abundant amount of rice to eat, and the total point-driven mode was for use by an individual who primarily desires a healthy and balanced diet. For example, if LT was 200 and UT was 300 for the

price-driven mode, this program sought the best menu within a range of 200 to 300 yen.

3. Results

Table 1. The best menu according to the price-driven mode
LT: lower threshold price, UT: upper threshold price,
R: sumR, G: sumG, Y: sumY, P: sumP,
EV: e_value, TP: total_P

LT	UT	main dish	side dish	soup	R	G	Y	P	EV	TP
0	30	------	------	------	0	0	0	0	nil	0
30	60	------	onsenegg	------	0.9	0	0	42	0.014	0.600
60	90	------	antouhu	------	0.9	0	0.9	84	0.009	0.750
90	120	------	renkonfry	------	0	0.7	2.4	105	0.012	1.217
120	150	------	onsenegg	imonijiru	1.3	0.5	0.5	147	0.010	1.533
150	180	imotaki	------	------	1.6	0.8	0.8	168	0.013	2.133
180	210	imotaki	onsenegg	------	2.5	0.8	0.8	210	0.012	2.483
210	240	imotaki	onsenegg	------	2.5	0.8	0.8	210	0.012	2.483
240	270	hamburg	------	------	1.4	1.3	3.7	252	0.011	2.700
270	300	sabani	renkonfry	------	3.7	0.8	3.2	273	0.010	2.800
300	330	imotaki	onsenegg	imonijiru	2.9	1.3	1.3	315	0.009	2.917
330	360	hamburg	touhu	------	2.1	1.4	3.9	336	0.009	3.000
360	390	hamburg	tetsuae	misosoup	2	1.5	4	367	0.008	3.000
390	420	keichan	onsenegg	imonijiru	3.2	1.1	2.3	399	0.008	3.000
420	450	hamburg	unohana	imonijiru	2.1	1.8	4.5	420	0.007	3.000
450	480	keichan	renkonfry	imonijiru	2.3	1.8	4.7	462	0.006	3.000
480	510	hamburg	hatahata	imonijiru	2.4	1.8	4.6	493	0.006	3.000
510	540	tonkatsu	hatahata	imonijiru	1.9	0.6	7.3	535	0.005	2.550
540	570	------	------	------	0	0	0	0	nil	0

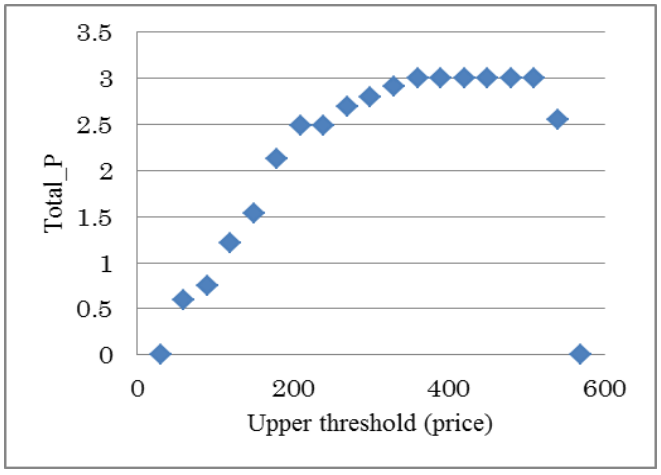


Figure 1. Upper threshold (price) versus Total_P

A positive correlation was observed between nutritive achievement and budget, as shown in Figure 1. The curve seemed to be saturated at 360 yen.

Between 30 yen and 210 yen, the Total_P and the UT seemed to have a linear relationship. This indicated that higher menu prices would produce more nutritional menus in this area. From 210 yen to 360 yen, the Total_P was saturated at the maximum value. This indicated that paying more for the meal only slightly contributes to increasing the nutritional quality of the menu. Between 360 yen and 510 yen, the Total_P was completely saturated. This indicated that 360 yen would be enough for the meal if only the nutritive achievement was considered. The small drop on the right side was simply because few menus cost 510 yen to 540 yen, and those menus did not have a good combination of dishes.

Table 2. The 25 best menus selected using the nutrition-driven mode when LT = NP = UT = 2
LT: lower threshold price, UT: upper threshold price,
R: sumR, G: sumG, Y: sumY, P: sumP,
NP: nutritive_P, TP: total_P

Rank	main dish	side dish	soup	R	G	Y	P	TP
1	imotaki	tetsuae	------	2.2	1.0	0.9	252	2.6833
2	hamburg	onsenegg	------	2.3	1.3	3.7	294	3.0000
3	imotaki	------	imonijiru	2.0	1.3	1.3	273	2.7667
4	imotaki	tetsuae	misosoup	2.2	1.0	1.1	283	2.7167
5	imotaki	onsenegg	imonijiru	2.9	1.3	1.3	315	2.9167
6	imotaki	harumaki	imonijiru	2.0	1.4	2.7	325	3.0000
7	hamburg	onsenegg	misosoup	2.3	1.3	3.9	325	3.0000
8	hamburg	touhu	------	2.1	1.4	3.9	336	3.0000
9	hamburg	tetsuae	------	2.0	1.5	3.8	336	3.0000
10	hamburg	antouhu	------	2.3	1.3	4.6	336	3.0000
11	imotaki	kinpira	imonijiru	2.0	1.6	1.8	336	2.9000
12	imotaki	unohana	imonijiru	2.3	1.3	1.6	336	2.8667
13	imotaki	hijikini	imonijiru	2.1	1.4	1.5	336	2.8333
14	imotaki	okura	imonijiru	2.0	1.5	1.5	336	2.8333
15	hamburg	yokosuka	------	2.0	1.3	7.1	357	3.0000
16	hamburg	torireba	------	2.2	1.3	4.2	357	3.0000
17	imotaki	antouhu	imonijiru	2.9	1.3	2.2	357	3.0000
18	imotaki	hourenso	imonijiru	2.0	1.5	1.3	336	2.8000
19	imotaki	komatsuna	imonijiru	2.0	1.4	1.4	336	2.8000
20	keichan	------	imonijiru	2.3	1.1	2.3	357	2.9500
21	imotaki	touhu	imonijiru	2.7	1.4	1.5	357	2.9333
22	hamburg	antouhu	misosoup	2.3	1.3	4.8	367	3.0000
23	hamburg	tetsuae	misosoup	2.0	1.5	4.0	367	3.0000
24	hamburg	touhu	misosoup	2.1	1.4	4.1	367	3.0000
25	imotaki	tetsuae	imonijiru	2.6	1.5	1.4	357	2.9167

Table 2 shows the list of menus with the full score in the red and green points. Table 2 is dominated mainly by imotaki.

Table 3. The 25 best menus based on the total point-driven mode when LT = TP = UT = 3
LT: lower threshold price, UT: upper threshold price,
R: sumR, G: sumG, Y: sumY, P: sumP,
NP: nutritive_P, TP: total_P

Rank	main dish	side dish	soup	R	G	Y	P
1	hamburg	onsenegg	------	2.3	1.3	3.7	294
2	hamburg	onsenegg	misosoup	2.3	1.3	3.9	325
3	imotaki	harumaki	imonijiru	2.0	1.4	2.7	325
4	hamburg	tetsuae	------	2.0	1.5	3.8	336
5	hamburg	touhu	------	2.1	1.4	3.9	336
6	hamburg	antouhu	------	2.3	1.3	4.6	336
7	hamburg	yokosuka	------	2.0	1.3	7.1	357
8	hamburg	torireba	------	2.2	1.3	4.2	357
9	imotaki	antouhu	imonijiru	2.9	1.3	2.2	357
10	hamburg	antouhu	misosoup	2.3	1.3	4.8	367
11	hamburg	tetsuae	misosoup	2.0	1.5	4.0	367
12	hamburg	touhu	misosoup	2.1	1.4	4.1	367
13	sanmafry	renkonfry	imonijiru	4.1	1.2	4.4	378
14	imotaki	yokosuka	imonijiru	2.6	1.3	4.7	378
15	imotaki	renkonfry	imonijiru	2.0	2.0	3.7	378
16	sanmayaki	renkonfry	imonijiru	4.1	1.3	2.9	378
17	sabani	renkonfry	imonijiru	4.1	1.3	3.7	378
18	hamburg	hatahata	------	2.0	1.3	4.1	388
19	hamburg	torireba	misosoup	2.2	1.3	4.4	388
20	hamburg	yokosuka	misosoup	2.0	1.3	7.3	388
21	hamburg	onsenegg	imonijiru	2.7	1.8	4.2	399
22	keichan	onsenegg	imonijiru	3.2	1.1	2.3	399
23	keichan	harumaki	imonijiru	2.3	1.2	3.7	409
24	hamburg	hatahata	misosoup	2.0	1.3	4.3	419
25	keichan	unohana	imonijiru	2.6	1.1	2.6	420

Table 3 is a list of menus with the full score in red, green and calorie points.

4. Discussion

Nutritional and inexpensive menus were recommended based on the budget and required nutrition.

From the shape of the graph in Figure 1 and Table 3, 300 yen was enough to purchase nutritious menu. From Table 2, even 250 yen was enough in terms of red and green points for a nutritious menu. In other words, more than 250 yen is necessary to purchase meals that help to maintain a healthy diet at “cafeteria Runeis”.

One of the problems with the results is that menus characterized as nutritious and inexpensive are tend to contain the same dishes. Nearly half of Table 2 is dominated by menus that include imotaki. Most of the menus in Table 3 include Hamburg steak. Even if the menu is nutritious and inexpensive, consuming a similar mealevery day is a practice that does not promote a healthy diet. Different types of menus should be available every day to help students maintain a healthy diet on a limited budget.

Another problem with the results is that the method of evaluating the nutrition of menus seems to be too simple. Foods are categorized into three groups (red, green and yellow) at the student refectory, and only the calories of the foods are counted. For example, miso soup contains seaweed and should be counted for its green point values; however, it is not evaluated in terms of calories. To find a more practical menu, more detailed and valid criteria, along with additional data, are needed. Other methods categorize foods into 4, 6 or 10 groups. The results from other methods should be compared with each other.

5. Conclusions

The program succeeded in determining nutritious and inexpensive menus by considering all possible combinations of menus and evaluating the nutritional value for each menu combination. However, the system needs to be improved to suggest variety of menus based on what students have already eaten recently.

6. References

[1] 京都大学生活協同組合. (2011). *栄養表示の見方*. Retrieved 2011, from 京都大学生活協同組合: http://www.s-coop.net/service/meal/nutritional/

[2] 山本　団. (2008). *technical master はじめての Ruby プログラミング*. 秀和システム.

[3] 女子栄養大学 基礎栄養学研. (2007). Retrieved 2011, from KNU　ダイエット: http://co-4gun.eiyo.ac.jp/Index.html

京都大学
KYOTO UNIVERSITY