Handedness and footedness in members of general Japanese population

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日本における成人のきき手ときき足について

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要約

本研究は、わが国におけるこれまでのきき手調査が主に大学生を対象として実施されてきたことを踏まえ、一般社会における成人のきき手およびきき足について調査し、その分布傾向と左ききき（ないし非右ききき）の発現要因について検討することを目的とした。H.N. きき手テストならびにH.I. きき足テストによる825名（19～89歳）への調査から、主要な結果として次の点が見いだされた。(1) きき手について、大学生のみを対象とした先行研究 (Hatta & Kawakami, 1995) の結果と比べ、今回の若年層グループ（19～29歳）では非右ききの発現率が高かった。(2) きき手・きき足ともに、若年層グループは中間層グループ（30～59歳）および老年層グループ（60～89歳）より非右ききの発現率が高かった。(3) 都市生活者と地方生活者との比較では、きき手の分布には違いが見られたがきき足については違いがなかった。これらの結果は、左ききの発現が脳における病理学的要因と関連している可能性を示すとともに、社会文化的要因の影響も受けていることを示唆している。

Key words

handedness, footedness, Japanese community dwellers, brain pathology, socio-cultural influence

1. Introduction

The aims of this study were threefold; First, to clarify the real left-handedness population among community dwellers in Japan and to compare the findings with previous studies about student populations; second, to determine the features of the footedness population in Japanese community dwellers, and third, to examine the effects of socio-cultural influences, mainly generation effects and living area effects, on handedness and footedness.

With regard to the first of these aims, the second author reported that in the 1970s, using a standardized handedness inventory, the left-handedness population of Japanese people was 3.09 % (Hatta & Nakatsuka, 1974; 1975). The percentages of the Japanese left-handedness populations in 1995 were 6.2 % in males and 4.2 % in females (the sum of mixed handedness and consistent left-handed was 12.8 % in males and 9.8 % in females; Hatta & Kawakami, 1995). The mixed handedness and consistent left-handed increased significantly in the female population during the 20 years following 1975. Shimizu and Endo (1983) also showed a relatively low percentage of consistent left-handed in comparison with various reports about Western society, namely that the male and female left-handed populations were 4.03 % and 3.39 %, respectively (e.g., Hatta, 1996; Porac & Coren, 1981).

However, these surveys were based on university student samples. When we take into consideration theories as to why people are born left-handed, the estimate of left-handed among student samples should be lower than the true one. We can assume that there are several theories as to why people are born left-handed; the genetic theory by Annett (1985) and McManus (1980), the pathological theory by Satz, Orsini, Saslow, and Henry (1985), and the hormonal theory by Geschwind and Garabulda (1984; 1985) and Witelson (1991). According to the last two theories, university students can be regarded as having experienced neither serious birth stress nor mild brain injury, and who have had the right level of androgen secretion in the uterus. Therefore, the incidence of left-handed in university students should be lower than in a general population, such as a community comprising various kinds of adults, not only intellectual people such as university students/graduates but also handicapped people, and those of mid and low intellect. This working hypothesis is based upon the fact that entrance examinations in Japanese higher education system are keen and mostly rely on verbal intelligence, therefore a person who has anomalous dominance (Geschwind's term) tend to be difficult to pass through the examination gate.

As far as we know, few surveys of the handedness of Japanese community dwellers have been reported, though several wide-ranging surveys have reported the handedness population among sample of university students (Hatta & Kawakami, 1995; Ida & Bryden, 1996; Shimizu & Endo, 1983). We had an opportunity to

administer the handedness survey in two communities, one in an urban and the other in a rural area. As this survey constituted a part of a health examination, seriously physically handicapped people did not participate. However, the results must be a better approximation to the general population than that based on university student samples.

The second and the third aims were based on the fact that no study has so far been conducted to clarify the features of footedness of the Japanese, and compared to handedness, few studies have been conducted on footedness in Western countries (Chapman, Chapman, & Allen, 1987; Coren, 1993; Porac, 1996; Searleman & Porac, 2001).

As the ages of our subject population varied from 19 to 89 years, a generational comparison of the left-handedness population became possible. As a matter of course, no generational comparison of Japanese community dwellers had been reported. Further, since we administered the survey in two communities, one from a rural and the other from an urban area, we could examine whether there was any difference between the samples of the two types of community, which might reflect socio-cultural influences on the incidence of left-handedness.

Recent questions regarding footedness have stimulated several interesting hypotheses (e.g., MacNeilage, Studdert-Kennedy, & Lindblom, 1993; Peters, 1988; Previc, 1991). Among them, it is the reasonable suggestion that footedness is less influenced by dextral social pressure and may be a better predictor of hemispheric specialization than handedness (Chapman, et al., 1987, Elias & Bryden, 1998; Peters, 1988).

However, it is not at all clear with regard to Japanese population how to evaluate footedness, the proportion of left-footedness, and whether there is a relationship between handedness and footedness. On the basis of our two surveys, we addressed these questions in this study.

2. Method

Eight hundred and twenty-five adults were given the H. N. handedness and the H. I. footedness inventories. Five hundred and seventeen were from the urban community near Nagoya City and 308 were from the rural area in Hokkaido. The inventories were administered as a part of health examination questionnaires by the health departments of city and town offices.

The H. N. Handedness inventory consisted of 10 items, and the H. I. footedness inventory consisted of 10 items. Precise information as to the H. N. handedness inventory was presented in previous studies (e.g., Hatta & Nakatsuka, 1974, 1975; Hatta & Kawakami, 1995). Factor analyses found that the H. N. handedness inventory consists of only one factor (hand preference) and the H. I. footedness inventory consists of two factors. The two factors are called pivoting and preference. The results of the factor analyses were reported elsewhere (Ito & Hatta, 2002). The items of both inventories are shown in Appendix 1.

3. Results and Discussion

3.1 Handedness

Table 1 shows the results of handedness incidence for males and females. Some participants made writing errors in the handedness inventory. In total 810 participants were analyzed. This table shows that the frequencies of mixed and consistent left-handed were 12.2 % in males and 10.7 % in females. These incidence rates do not seem to be too low in comparison with Western countries (Ida & Bryden, 1996; Oldfield, 1971; Reiss & Reiss, 1997). However, the incidence rate of consistent left-handed does seem to be lower than that of Western countries. The sex difference was statistically not significant ($\chi^2(2) = 0.70$) and this was consistent with the previous study with a university student population in 1995 (Hatta & Kawakami, 1995). Regarding sex difference in handedness, many previous studies in foreign countries found that the incidence of left-handed in males was greater than that in females (Bryden, 1977; Coren, 1994; Hardyck, Goldman, & Petrinovitch, 1975; Hugdahl, Zaucha, Mitrushima, & Miler, 1996; Oldfield, 1971). The present findings show that the handedness feature in modern Japanese community dwellers is exceptional.

Table 1: Frequencies of handedness and footedness as a function of sex

	Left	Mixed	Right
Handedness			
Male (*N*=230)			
Number	10	18	202
Percent	4.3	7.8	87.8
Female (*N*=580)			
Number	26	36	518
Percent	4.5	6.2	89.3
Total (*N*=810)			
Number	36	54	720
Percent	4.4	6.7	88.9
Footedness			
Male (*N*=220)			
Number	17	67	136
Percent	7.7	30.5	61.8
Female (*N*=565)			
Number	11	131	423
Percent	1.9	23.2	74.9
Total (*N*=785)			
Number	28	198	559
Percent	3.6	25.2	71.2

Table 2 represents non-right-handers' frequencies as a function of three age categories and sex. The comparison of the samples of Japanese students by Hatta and Kawakami (1995) and the young group (19-29 years old) of community dwellers in this study suggested that the incidence of mixed and consistent left-handed in community dwellers (22.3 %) was higher than that of the univer-

Table 2: Frequencies of mixed and consistent left-handed/footed as a function of three age categories and sex

	19-29 years old	30-59 years old	60-89 years old
Handedness	(N = 229)	(N = 230)	(N = 351)
Males			
Number	20	4	8
Percent	8.7	1.7	2.3
Females			
Number	31	12	14
Percent	13.5	5.2	4.0
Total			
Number	51	16	22
Percent	22.3	7.0	6.3
Footedness	(N = 221)	(N = 225)	(N = 339)
Males			
Number	40	9	35
Percent	18.1	4.0	10.3
Females			
Number	45	45	52
Percent	20.4	20.0	15.3
Total			
Number	85	54	87
Percent	38.5	24.0	25.7

sity students reported in 1995 (10.7 %) ($\chi^2(1) = 25.42$, $p < 0.01$), even though the subjects' ages did not necessarily fully correspond. This finding seems to support with the proposal of pathological left-handers theory (Satz, et al., 1985). That is, university students are regarded as those who have not experienced functional deficit due to the brain pathology, while some of the community dwellers might have brain functional deficit (even very mild).

Table 2 also shows the generation difference. There was a significant difference among three age groups ($\chi^2(2) = 40.34$, $p< 0.01$). Further analyses revealed that the frequency of mixed and consistent left-handed in the young age group was higher than that of the other two groups ($\chi^2(1) = 21.59$ and 32.26, $p < 0.01$), whereas no difference was found between intermediate (30-59 years old) and old (60-89 years old) age groups ($\chi^2(1) = 0.11$). These results show that there was a clear generation boundary on around 30 years old, in other words, between those who were born before and those born after about 1970.

The tendency of a cohort effect of increasing mixed and consistent left-handed was not only reported in Japanese people, but also in Israeli, British and Norwegian people. Kobyliansky, Micle, and Arenburg (1978) reported that 15.5 % of Israel-born subjects were left-handed as compared with only 5.9 % of the previous generation who were not born in Israel. Fleminger, Dalton, and Standage (1977) found that in a British sample, left-handed writing was inversely related to age, ranging from 2.9 % among people born in 1912-1922 to 10.8 % among people born in 1963-1973. In Norway, the incidence of left-handed writing rose across three generations between 1920 and 1980, from 1.2 % for the first generation to 8.7 % for the third generation (Tambs, Magnus, & Berg, 1987). A similar picture emerged for the 20 years between 1973 and 1993 in the Japanese student population, where the incidence of mixed and consistent left-handed increased significantly from 6.0 % to 9.8 % in females, although it remained at a similar level in males, from 11.5 % to 12.8 % (Hatta & Kawakami, 1995).

This finding about the generation difference seems to reflect a social background of historical change in Japanese society. After the end of World War II, the Japanese people have been put through the mill by sluggish economical development for nearly 20 years. However, after that, the economical conditions in Japan have improved considerably and economical development has changed not only the socio-economical conditions but also the mentality of the Japanese for better or worse. The 1970s are regarded as an epoch making era in modern Japanese history. The life style, including the use of various kinds of appliances, has become completely westernized and those changes seem to have fostered an increase in mixed and consistent left-handed, or introduced a similar incidence rate of mixed and consistent left-handed to that of the western countries.

Table 3 shows the handedness distribution of urban and rural community dwellers. The comparison of the handedness in urban and rural community dwellers shows that the incidence of mixed and consistent left-handed in urban dwellers (13.2 %) was higher than that of rural dwellers (7.1 %) ($\chi^2(1) = 7.10$, $p < 0.01$).

These different distributions of handedness between urban and rural community dwellers as well as between different generations suggest that socio-cultural demands can be regarded as one

Table 3: Frequencies of handedness and footedness in urban and rural community dwellers

	Left	Mixed	Right
Handedness			
Urban (N=515)			
Number	24	44	447
Percent	4.7	8.5	86.8
Rural (N=295)			
Number	9	12	274
Percent	3.1	4.1	92.9
Total (N=810)			
Number	33	56	721
Percent	4.1	6.9	89.0
Footedness			
Urban (N=507)			
Number	14	137	356
Percent	2.8	27.0	70.2
Rural (N=283)			
Number	14	63	206
Percent	4.9	22.3	72.8
Total (N=790)			
Number	28	200	562
Percent	3.5	25.3	71.1

of the crucial contributing factors in changes of handedness incidence patterns in Japanese society (Bishop, Ros, Daniels & Bright, 1996; De Agostini, Khamis, Ahui, & Dellatolas, 1997; Hatta & Kawakami, 1995; Ida & Bryden, 1996; Porac & Coren, 1981; Reiss & Reiss, 1997; Springer & Deutsch, 1998).

3.2 Footedness

Table 1 also shows the incidence of footedness as a function of sex. As some of the participants made writing errors, the data of 785 participants in total was analyzed. According to the criteria of the H. I. Footedness Inventory, scores of up to 4 refer to right footedness, less than -3 refer to left footedness, and the others refer to mixed (scores ranged from +10 for the right to -10 for the left). The examination of sex difference shows that the incidence of right footedness in female participants was significantly higher than that in males ($\chi^2(2) = 21.94, p < 0.01$).

The generational difference in footedness was also examined (Table 2). The result showed that there was a significant difference among three age groups, young, intermediate, and old ($\chi^2(2) = 14.22, p < 0.01$). Further analyses revealed first, that the incidence of right footedness in the young group was lower than that of the other two age groups ($\chi^2(1) = 10.87$ and $10.30, p < 0.01$), and second, that there was no difference in the incidence of right footedness between the intermediate and old age groups ($\chi^2(1) = 0.20$). This generation difference seems to reflect the socio-cultural influence on the incidence of footedness as well as that of handedness.

As mentioned earlier, nothing has been reported on the incidence of the footedness distribution in a Japanese sample. The present study showed that the incidence of right footedness in Japanese general population is 71.2 %, of left footedness 3.6 %, and of mixed 25.2 %. Previous reports for foot preference, which were based on the questionnaires with more than three items (unilateral motor performances) suggest that the incidence of right footedness is generally 80 % and of left footedness 6-8 %. Gentry and Gabbard (1995) reported that the incidence rate in American 13-20 years old participants of right footedness was 79 % and of left footedness was 6 %. Coren (1993) also reported that the incidence of right footedness in Canadian 17-35 years old adults was 79 % and left footedness was 5 %. We must be cautious in comparing the footedness distribution between the various reports, as the operational definition of the preference is not necessarily identical among researchers and some previous study employed right-left split type questionnaires. However, a direct comparison suggests a cultural difference, in that there is less left footedness in Japan than in the USA and Canada. The lower left side preference in the Japanese has already been reported, and the result of the present study is coincident with hand preference (e.g., Hatta & Nakatsuka, 1974).

The comparison of footedness in urban and rural community dwellers shows that the incidence of mixed and consistent left-footed in urban dwellers (29.8 %) was largely the same as that of the rural dwellers (27.2 %). As shown previously, there was a significant difference between urban and rural dwellers in handedness but this was not the case with regard to the footedness distribution. This discrepancy seems to suggest that cultural and social influences are stronger on hand use than on foot use in the course of human development.

4. Conclusion

In conclusion, the fact that the incidence of mixed and consistent left-handed in young community dwellers was greater than that of the university student population shown in previous Japanese handedness studies seems to support the claim that pathological brain function is a factor of left-handed, in accordance with the Satz's birth stress theory (Satz, et al., 1985) and the Geschwind's hormonal theory (Geschwind & Garabulda, 1984; 1985). Further, the present survey also strongly suggests that a socio-cultural factor as well as a pathological brain function influences the incidence of handedness and footedness patterns, but that the influence is differential between handedness and footedness.

As one may have already noticed, the sample distributions in sex, age groups, and living area were not necessarily sufficient. More data have to be collected in future studies to examine the degree of socio-cultural influences on the activity of the upper and lower limbs. In addition, the examination of the interaction between upper and lower limbs should be addressed in further study.

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Appendix 1

H. N. Handedness Inventory

Types of uni-manual behavior?	Left	Both	Right
Rubbing out by eraser			
Striking a match (stick holding)			
Cutting with scissors			
Using a knife (without fork)			
Using a screwdriver			
Shaving (lip stick)			
Pinning down			
Tooth brushing			
Throwing a ball			
Hammering			

H. I. Footedness Inventory

Types of behavior?	Left	Both	Right
Kicking the ball at the midline of the body			
Standing on one foot			
Smoothing sandbox by one foot			
First step in going up the stairs			
Catching moving small thing by one foot			
Keeping balance on one foot			
Picking up a pebble by toe			
Hopping on one foot			
Foot on the shovel in digging hole			
Foot of sustaining body when standing at ease			

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