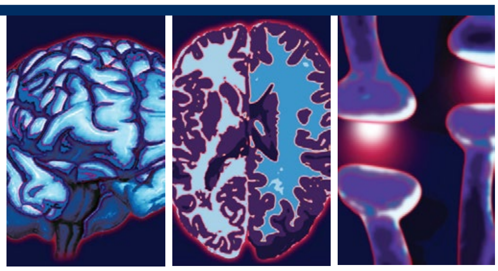


Effect of an auxiliary device for chopstick operations on the chopstick-use performance of foreign novices

Yi-Lang Chen[1,†], Yu-Chi Lee[2]

ABSTRACT

This study adopted the chopstick auxiliary device which was previously developed to assess how such a device improves the chopstick-use performance of foreign novices. Fifty male international exchange students participated in the study and their data on three food-serving performance indicators were collected after they performed three stages of tasks. Results showed that after users whose original chopstick operation was scissors-pinching had practiced using the auxiliary device for 1-h, the precision and stability of their pincers-pinching operation was superior to those of their scissors-pinching technique (p<.05). This study also found that the auxiliary device is applicable for novices who already knew how to use chopsticks correctly (i.e., pincers-pinching). Using this device significantly improved their pinching force, whereas the pinching precision and stability remained no significant change. This study verified that foreigners who just started using chopsticks can employ the auxiliary device to learn how to correctly hold chopsticks, thereby improving their food-serving performance.

Keywords

Chopsticks, Pincers-pinching operation, Scissors-pinching operation, Auxiliary device, Foreigner

Introduction

In a majority of Asian countries, chopsticks are the primary eating utensils. In China, approximately 3500 years ago, chopsticks were invented and used as a utensil for serving food. People can use chopsticks with one hand to pick up hot cooked foods (thus avoid burning themselves) and even tear and cut softer foods. Chopsticks can be considered an extension of one's hands and are considerably different from the knives and forks used in Western countries. The recent rise of Chinese culture has attracted the attention of non-Asian people in using chopsticks as eating utensils. Moreover, the ability to use chopsticks skillfully even became an indicator of identity.

However, few studies involving the use of chopsticks in foreign countries have been conducted because of differences in culture and the food consumed and because Western countries generally use knives and forks. Most studies have focused on the ergonomic evaluations of knives and forks [1]. Ergonomic issues concerning chopsticks have only started to attract attention in the past 25 years, during which research on the optimization of chopstick appearance and geometric dimensions has been conducted. Hsu and Wu [2] discussed the effect of chopstick length on food-serving performance; they found that chopstick length significantly influenced food-pinching performance, and that chopsticks of about 240 and 180 mm long were optimal for adults and pupils, respectively. Determining the chopstick

[1]Department of Industrial Engineering and Management, Ming Chi University of Technology, and Department of Industrial Design, Chang Gung University, Taiwan

[2]School of Mechanical and Aerospace Engineering, Nanyang Technological University, Singapore

[†]Author for correspondence: Dr. Yi-Lang Chen, Professor, Department of Industrial Engineering and Management, Ming Chi University of Technology, 84, Gungjuan Rd., Taishan Dist, New Taipei 24301, Taiwan. Tel: +886-2-29089899, ext: 3103, Fax: +886-2-29085900, email: ylchen@mail.mcut.edu.tw

diameter significantly influenced food-pinching performance, Wu [2] and Chan [3] suggested that chopsticks with a 6 mm handle diameter, a 2° tip angle, and a 4mm tip diameter would be optimal for food-serving performance. Chen, *et al.* [4] investigated the effectiveness of chopsticks with different shapes and tips and suggested that chopsticks with round handles and grooved tips should be used.

In addition to the shape designs, methods of holding chopsticks are also crucial for investigation. Generally, chopstick operations can be classified into two modes, namely pincers-pinching and scissors-pinching **(Figure 1)**. Using chopsticks requires skillful and precise finger motions, and different modes of operations result in distinct food-serving performance. In pincers-pinching, one stick passes through the space between the thumb and first finger; it is held against the flesh at the side of the ring finger so the stick cannot move. The other stick is held by the middle and index fingers so that they can move apart or together and thus bring morsels to the mouth. The operation of pincers-pinching can be classified as third-class lever [5]. In scissors operation, two sticks cross each other between the thumb and the index fingers, and force is applied to them by the interior sides of the thumb and index fingers when the tips of the index and middle fingers just hold and aid the sticks. Corresponding to the pinching mechanism, its operation can be classified as first-class lever [6]. Chen, *et al.* [4] conducted a questionnaire survey of chopstick type and pinching operations on 412 adults in Taiwan and determined that approximately half of the respondents use the pincers-pinching mode, whereas the other half adopt the scissors-pinching operation. Tang [7] presented the survey results provided by Japan's Ministry of Education, Culture, Sports, Science and Technology, which reported that only 48.4% of 15,400 elementary school third and sixth graders were able to use chopsticks correctly. Chen [6] evaluated the effect of chopstick operations on food-serving performances and experimentally determined that pincers-pinching operations rendered a significantly higher pinching precision and stability. Chen also indicated that the scissors-pinching group gave a more powerful pinching force while pulling the experimental food. This result was attributed to the different modes of operations used; when using scissors-pinching mode, chopstick users tend to use their palm grasp force to perform grasp-like actions. Ho and Wu [8] investigated the mode of grasp, materials, and grooved chopstick tip and indicated that a combination of bamboo chopsticks with grooved tips used with a pincers-pinching operations is preferable for a more favorable food-serving performance. Similar results were reported by Chang, *et al.* [9]. In summary, the mode of chopstick operation is a crucial factor influencing food-serving performance, and the results of previous studies also consistently indicate that pincers-pinching operation is the optimal mode for using chopsticks.

To facilitate the correct use of chopsticks, numerous chopstick auxiliary devices have been proposed, and these devices have been developed and designed for specific populations. Chang, *et al.* [9] proposed a chopstick auxiliary device for patients with hand dysfunction; their simulation results revealed that the food-serving performance of patients when using the auxiliary device was higher than that when they used a spoon. However, the patients were not accepting of the proposed device because the design focused overly on the functional aspect of the chopstick. Lee and Chen [10] designed an auxiliary device for chopsticks operation (Figure 2). In their experimental evaluation, the subjects who generally use the scissors-pinching method effectively learned the pincers-pinching method after 1-h of training using the auxiliary device. In addition, their food-serving performances were improved, verifying the effectiveness of the device in correcting chopstick operations. Chen and Lee [11] then conducted a follow-up study and revealed 1-month retention of the pincers-pinching skill. In general, auxiliary device for holding chopsticks is designed for only patients and children. For novices in using chopsticks (such as non-East Asian people), providing an effective auxiliary device can help them quickly learn how to use chopsticks correctly. Therefore, on the basis of the auxiliary device design proposed by Lee and Chen [10], this study evaluated the learning outcome of foreigner novices using the auxiliary device for chopsticks operation. Subsequently, the effectiveness of the auxiliary device was evaluated through a simulation of food-serving tasks.

Method

■ Participants

In this study, 50 male international students were recruited as the participants; 20 of these students originally operated chopsticks by using the pincers-pinching mode (aged 19-35 yrs; average age, 25.15 yrs) and 30 of them originally operated chopsticks by using the scissors-pinching mode (aged 20-35 yrs; average age, 26.77 yrs). Both the pincers-pinching users and scissors-pinching users have lived in Taiwan for 2-6 months when the experiments were implemented. The participants' information is presented in **Table 1**. Among the 50 exchange students, five were from Australia, 16 from the United States, six from European countries, eight from African countries, and 15 from Asian countries (Indonesia and India). Regarding the main eating utensil, 40% of the participants primarily used spoons, 27% used knives and forks, 15% used a mix of eating utensils, and 18% ate with their bare hands. Because the participants lived in Taiwan for study purposes, they must get accustomed to using chopsticks as their daily eating utensil. All the participants were right handed and had no history of hand injuries. Prior to data collection, the authors of this study clearly explained the experimental procedure and purpose to the participants. Informed consent was obtained from all participants, and the Ethics Committee of National Tsing Hua University (Taiwan) approved this study.

■ Experimental chopsticks

This study employed bamboo chopsticks, which are commonly used in Taiwan and were purchased from a typical supermarket. The bamboo chopsticks were 220 mm long, with 30 mm tip length, grooved tips, a 6 mm handle diameter, a 4mm tip diameter, and a 2° tip angle. The external geometric design of the chopsticks conformed to the optimal configuration described in previous studies [2,5,6,8,11]. The chopstick auxiliary device design was based on Lee and Chen [10] **(Figure 2)**.

■ Simulated food-serving experiment and performance indicators

In the experiment, three simulated food-serving tasks examined in Chen [6] were performed in the present study to measure the pinching force, precision, and stability, as shown in **Figure 3**. The experimental procedures are detailed as follows.

(1) Food-pulling experiment

This experimental setup was adapted from Chen [6]. When the experiment began, the participants used chopsticks to grip a rubber eraser (60×60×60 mm) placed in front, 450 mm away from the participant, and pulled it from the table toward the mouth until it slipped off. A pushpull tester (MP-1, Attonic, Japan) was used to read the maximum pulling force. This experiment was repeated twice and the average of the obtained readings was used in the subsequent analysis.

(a) (b)

Figure 1: Definition of the (a) scissors-pinching and (b) pincers-pinching operations.

(a) (b)

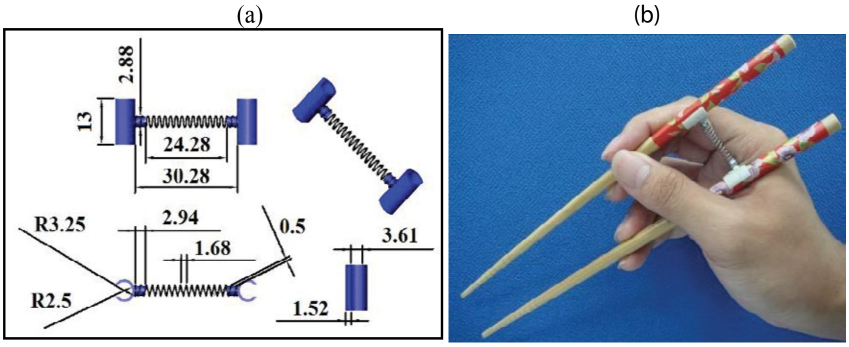
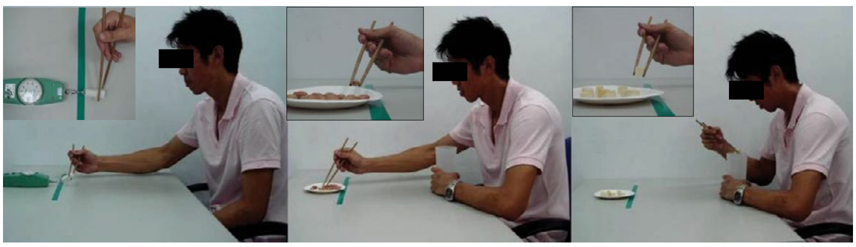


Figure 2: Diagram showing (a) the dimension (unit in mm) of the chopstick auxiliary device and (b) chopsticks connected to the auxiliary device (adopted from the study of Lee and Chen in 2008).

Table 1: Basic information of the participants.

	Pincers-pinching group (n=20)			Scissors-pinching group (n=30)		
	Min.	Max.	Mean (SD)	Min.	Max.	Mean (SD)
Age (yrs)	19	35	25.15 (3.77)	20	35	26.77 (3.87)
Stature (cm)	162	180	169.59 (9.69)	162	185	167.84 (7.25)
Body mass (kg)	58	88	64.42 (11.64)	52	90	67.17 (10.03)
Hand length (mm)	151	215	181.50 (1.58)	160	199	179.70 (0.98)
How long had been Taiwan (months)	2	6	3.60 (1.43)	2	6	4.20 (1.50)



food-pulling task food-pinching task food-moving task

Figure 3: Three simulated food-serving tasks performed in this study.

(2) Food-pinching experiment

The participant sat on an adjustable seat, and picked up 30 peanuts one by one from a dish (120 mm diameter) placed in front, 450 mm away from the participant, and moved them to a cup (150 mm high and 80 mm in diameter), which was placed on the table right below the participant's mouth. The time spent on picking up all 30 peanuts was recorded. This experiment was repeated twice and the average of the obtained readings was used in the subsequent analysis.

(3) Food-moving experiment

Similarly, following the procedure described by Chen [6], the participant sat on an adjustable seat, and picked up10 cubes of bean curds (1.5 cm×1.5 cm×1.5 cm), one by one, moving it from a dish to a cup placed below the participant's mouth. The experimental setup for this task was similar to that for the food-pinching experiment. This experiment was repeated twice and the average of the obtained readings was used in the subsequent analysis.

Peanuts are small and picking them up is difficult and requires a high degree of precision. Bean curds are delicate and soft. Therefore, when moving bean curds, the participants must apply force steadily to complete the test. Hence, peanuts and bean curds were used as measures for evaluating pinching precision and pinching stability [6].

■ Experimental procedure

Before the experiment commenced, the participants first adjusted their seat to a comfortable height and practiced the three food-serving tasks to familiarize themselves with the entire experimental procedure. Each participant had no prior experience in using the auxiliary device used in this study. The order of experimentation was randomized for each participant.

To assess the effectiveness of using the auxiliary device to learn how to use chopsticks, this study referenced the research by Lee and Chen [10] and conducted the experiment in three stages: Stage I: the participants used the chopsticks by using their original mode of operation; Stage II: the participants practiced using the auxiliary device for 1-h, after which they used the device to perform the pincers-pinching operation; and Stage III: the participants performed the pincers-pinching operation without using the auxiliary device. For each stage, the participants had to complete the three simulated food-serving tasks (i.e., pulling the simulated rubber eraser, picking up the 30 peanuts, and picking up 10 pieces of bean curds). The numbers of the peanuts and the bean curds picked up in the experiment were determined by a pilot-test to trade-off between the satisfying pinching time and avoiding fatigue of fingers. In each stage, the participants were allowed a 5-min rest period to prevent their fatigue from influencing the test.

■ Data analysis

The experimental data collected in this study were analyzed using SPSS Version 19.0, with confidence level set to .05. Analysis of variance (ANOVA) was used to determine whether the independent variables influenced participants' performance in the food-serving tasks. Duncan's multiple range test (MRT) was adopted to examine the difference among the significant variables. Regarding different sample groups, independent *t* test was conducted to examine the difference in the learning outcome of pincers-pinching and scissors-pinching groups after using the auxiliary device.

Results

Table 2 shows ANOVA results of the food-serving performance of participants whose original chopstick operation was the scissors-pinching mode. The results indicated that the data of each indicator for the operation performed in the same stage differed significantly ($p<.05$). Regarding the pinching force, the force of the scissors-pinching mode in Stage I was the largest at 0.55 kg. Regarding precision and stability, the participants performed the most optimally in the pincers-pinching operation without using the auxiliary device (Stage III), with a recorded time of 80.10 s and 30.07 s for pinching precision and stability, respectively. The Duncan's MRT result indicated that after an hour of training, the participants' performance at Stage III (pincers-pinching without auxiliary device) was superior to that at Stage I (original operation: scissors-pinching).

Table 3 presents the means, standard deviations, and ANOVA results of the food-serving performance of participants whose original chopstick operation was the pincers-pinching mode. The experimental results indicated that only the force indicator for the operations performed at the different stages demonstrated significant difference (p<.05). The Duncan's MRT result indicated that an hour of training facilitated improving the participants' pinching forces. Concerning performance, the pinching force (0.50 kg), precision (78.30 s), and stability (25.40 s) exhibited the most optimal performance at Stage III; however, the pinching precision and stability did not improve significantly in Stage III.

Table 2: Food-serving performances and Duncan's MRT results (users originally using scissors-pinching mode, n=30).

	Pinching force (kg)		Pinching precision (s)		Pinching stability (s)	
Stage I: Original operation (scissors)	0.55 (0.11)	A	87.68 (8.72)	A	35.43 (9.38)	A
Stage II: Use auxiliary after 1hr	0.44 (0.09)	B	86.22 (10.02)	A	36.07 (9.90)	A
Stage III: Without auxiliary (pincers)	0.48 (0.11)	B	80.10 (8.07)	B	30.07 (8.19)	B
***p* value**	0.001		0.004		0.025	

Table 3: Food-serving performances and Duncan's MRT results (users originally using pincers-pinching mode, n=20).

	Pinching force (kg)		Pinching precision (s)	Pinching stability (s)
Stage I: Original operation (pincers)	0.37 (0.11)	A	82.30 (7.22)	28.83 (8.79)
Stage II: Use auxiliary after 1hr	0.44 (0.12)	A B	80.23 (7.80)	27.68 (4.86)
Stage III: Without auxiliary(pincers)	0.50 (0.10)	B	78.30 (7.88)	25.40 (6.93)
***p* value**	0.001		0.262	0.301

Discussion

Previously, Chen [6] indicated that the pinching precision and stability of users who performed pincers-pinching were superior to those of the users who performed scissors-pinching, whereas the pinching force of the users who performed scissors-pinching was more powerful than that of the users who performed pincers-pinching. The result was also verified by Lee and Chen [10]. In the present study, after 1-h of pincers-pinching training, users whose original chopstick operation was scissors-pinching mode performed better in pinching force than they did earlier, as shown in **Table 2**. However, they performed poorly in terms of pinching precision and stability. The Duncan's MRT results revealed that the pinching force, precision, and stability differed significantly in Stages I (scissors-pinching) and III (pincers-pinching). This result was consistent with the aforementioned research results. The results of the present study verified that the chopstick auxiliary device is not only helpful for correcting chopstick holding postures but also effective for helping beginners who have just learned how to correctly use chopsticks (pincers-pinching). After using the chopstick with the assistance of an auxiliary device, the 20 international exchange students who originally used the pincers-pinching method to operate chopsticks showed significantly improved pinching force and slight improvement in the other two indicators (i.e., pinching precision and stability). Interestingly, after an hour of training in using the auxiliary device, the participants performed better (irrespective of whether the difference was statistically significant) in Stage III (without auxiliary device) in the three food-serving tasks than they did in Stage II (with the auxiliary device), regardless of their original operation (pincers- or scissors-pinching). Thus, after an hour of training, the participants were free from the restraint of the auxiliary device and therefore were able to move their fingers flexibly and effectively.

To determine the effect of the chopstick auxiliary device on users with different original chopstick operations, independent t test was used for examining the simulated food-serving performance of users performing pincers-pinching and scissors-pinching operations after 1-h of using the auxiliary device. The results are shown in **Table 4**. After 1-h of training with the auxiliary device, the users performing pincers-pinching operation performed better than the users performing scissors-pinching operations did in pinching precision (p<.05). This reveals that the effect of the auxiliary device on the users who used scissors-pinching was more apparent than that on the users who used pincers-pinching. However, using chopsticks requires extremely precise finger motions and the use of a great deal of joints and 50 muscles; therefore, enabling the participants to get accustomed to using the pincers-pinching operation within a short time is difficult. For users whose original chopstick operation is the pincers-pinching mode, they were able to improve their pincers-pinching posture after using the auxiliary device. This may explain why the users who used pincers-pinching still performed better in terms of pinching stability after 1-h of training compared with the users who used scissors-pinching. In addition, the potential implication of the auxiliary device for chopstick operations for the neuropsychiatry-related patients merits further investigation.

Table 4: Food-serving performances of the participants with different original chopstick operations after 1-h of training using the auxiliary device.

		Stage III: without auxiliary (pincers-pinching)		
	N	Pinching force (kg)	Pinching precision (s)	Pinching stability (s)
Original scissors-pinching	30	0.48 (0.11)	80.10 (8.07)	30.07 (8.19)
Original pincers-pinching	20	0.50 (0.10)	78.30 (7.88)	25.40 (6.93)
***p* value**		0.493	0.439	0.041

Training duration is a crucial factor influencing the effectiveness of auxiliary device training. This study only collected data after 1-h of training for analysis. Long-term follow-up study can be conducted in the future to determine the retention effect of the auxiliary device. In this study, the auxiliary device was adapted from Lee and Chen [10]; however, the hand dimensions for foreigners (mean 180 mm in this study) and Taiwanese people (mean 171 mm, reported by Institute of Labor, Occupational Safety and Health, Ministry of Labor, Taiwan, 2008) differ significantly. Therefore, the size of the auxiliary device should be increased adequately to adjust it to a size more suitable for the palm of foreigners, which should also enhance the correction effect of the auxiliary device.

Conclusion

This study adopted the chopstick auxiliary device proposed by Lee and Chen [10] to evaluate the food-serving performance of foreign novices. The results revealed that after users whose original chopstick operation was scissors-pinching underwent 1-h of training with the auxiliary device, the precision and stability of their pincers-pinching operation were superior to than that exhibited before the training using the scissors-pinching operation. However, their pinching force decreased slightly. For users whose original chopstick operation was pincers-pinching, their overall food-serving performance also improved, specifically with regards to pinching force. This study verified that regardless of their original mode of chopstick operations, novice chopstick users can effectively learn how to hold chopsticks correctly and improve their food-serving performance through 1-h training using the auxiliary device [12,13].

Acknowledgement

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