Development of a “Facial Rock-Paper-Scissors” program for rehabilitation of swallowing and cognitive functions that has psychological effects

Yoshioka, Kiyomi
Meisei University, Hino, Tokyo, Japan
kiyomi.yoshioka@design.meisei-u.ac.jp
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We have developed a “Facial rock-paper-scissors” program that maintains and improves cognitive and swallowing functions by incorporating mouth and cheek movements and voicing, which are part of swallowing training, into a response-type facial rock-paper-scissors game with oral-facial movements. The expression of “scissors,” formed by horizontally stretching the mouth and raising the corners of the mouth, is expected to have the psychological effect of smiling to improve mood. We conducted a psychological evaluation of changes in mood during the “Facial rock-paper-scissors” program using the Profile of Mood States Short-Form (POMS-SF) and Two-Dimensional Mood Scale Short-Term (TDMS-ST) methods, and confirmed the psychological effect of the program on improving mood. Based on these results, we developed an app to run the “Facial rock-paper-scissors” program on a tablet device.

Keywords: rehabilitation program; app; swallowing and cognitive functions; psychological effects

1 Introduction

As of 2021, pneumonia and aspiration pneumonia were respectively the fifth and sixth leading causes of mortality in Japan, together accounting for 8.5% of all deaths. By age group, the proportion of pneumonia increases with advancing age, ranking fourth for ages 65 and higher, and third for ages 85 and higher (Ministry of Health, Labour and Welfare Summary of Vital Statistics of Population, 2021). Given that approximately 70% of patients with pneumonia are aged 75 or older, and more than 70% of these patients have aspiration pneumonia (The 2nd Working Group Meeting on Home Medical Care and Partnership for Medical and Nursing Care, the Ministry of Health, Labour and Welfare, 2016), urgent action is needed to combat aspiration pneumonia in today’s rapidly-aging society.

Research and other efforts in the medical field have shown that mouth, tongue, and cheek exercises used as swallowing training, and rehabilitation to maintain and significantly improve swallowing function, successfully increase saliva secretion and improve feeding and swallowing functions (Takeghara, I. et al., 2014; Omori, T. et al., 2016; Seirei Hamamatsu City Rehabilitation Hospital, 2023).
As a practical example of efforts aimed at maintaining and improving cognitive function, one study in Japan reported on the effects of public awareness programs at community general support centers designed to prevent frailty. These results suggest that performing the task of responding orally and facially to rock-paper-scissors may also lead to maintenance and improvement of cognitive function (Anai, M. et al., 2001). In that study, “rock” was expressed by pursing the lips and bringing the eyes and eyebrows close together, “scissors” was expressed by putting out the tongue, and “paper” was expressed by opening the eyes and mouth widely. In the facial rock-paper-scissors game, the subject must instantly recognize the opponent’s facial expression as rock, paper, or scissors, and then make a facial expression that beats their opponent’s choice. Since the subject performs conversion and reconversion processing of stimulus information, which is presumed to be susceptible to aging, the task is expected to maintain and improve cognitive function. Based on these previous studies, we considered that it would be possible to perform rehabilitation to maintain and improve swallowing and cognitive functions by developing a new program that would simultaneously provide swallowing training and a response-type facial rock-paper-scissors exercise with oral-facial movements.

When people see another person with a smiling face, their own facial expression also reacts in a synchronous manner, resulting in a transmission of emotions that makes them feel happy (Hinsz, Z. B. et al., 1991; Hatfield, E. et al., 1992). It has been shown that not only actual persons’ smiles but also images and photographs of smiling persons cause similar reactions (Ichikawa, H. et al., 2002). In previous studies, we verified the synchronous response of smiling using a self-drawn icon of a smiling face (composed of simply-shaped eye and mouth parts), and the resulting psychological effect of improved mood (Yoshioka, K. 2016, 2017). Based on these previous studies, we thought that incorporating design elements that induce people to smile in the program developed in this study will also have the psychological effect of improving mood.

This study aims to develop a “Facial rock-paper-scissors” program that incorporates smile-inducing design elements and in which swallowing training and response-type facial rock-paper-scissors exercise are performed simultaneously. This program adds psychological benefits to rehabilitation for maintaining and improving swallowing and cognitive functions. The study also investigates the psychological effects of implementing the newly developed “Facial rock-paper-scissors” program. An app has also been developed to be able to run the program easily on Android and Apple tablets.

2 Development of a “Facial rock-paper-scissors” program (patent pending)

We devised a “Facial rock-paper-scissors” that replaces the mouth and cheek movements and voicing that are included in swallowing training (Takeghara, I. et al., 2014) with facial expressions and voicing in a response-type rock-paper-scissors game that involves oral-facial movements. In Japan, ‘rock-scissors-paper’ is respectively represented vocally as guu, choki and paa. When facially expressing “paper” in the rock-paper-scissors program, the vowel at the end of the syllable paa is stretched to pronounce aaa by opening the mouth widely in all directions, creating a mouth and cheek exercise. In facially expressing “scissors,” the vowel at the end of the word choki is stretched to pronounce ii by stretching the mouth widely and horizontally to perform another mouth and cheek exercise. In facially expressing “rock,” the vowel at the end of the syllable guu is stretched to pronounce uuu by pursing the mouth to perform a third type of mouth and cheek exercise. The program incorporates swallowing training to maintain and enhance the swallowing function using a response-type rock-paper-scissors exercise.
game with oral-facial movements to also maintain and improve cognitive function. In this program, for which a patent has been applied, the expression of “scissors,” formed by horizontally and widely stretching the mouth and raising the corners of the mouth, is expected to have the psychological effect of smiling to improve mood (Fig. 1). Furthermore, the images presented in the "Facial rock-paper-scissors" program use rather abstract face illustration images, which are considered to have little individual difference in suitability (preference) for faces. In addition, the app's interface is based on universal design, such as adding phonetics to the complex written characters (kanji), and enlarging the characters so that the interface can be used by a wide range of age groups. If the program interface language is changed, the program may be used in any country.

Figure 1. Images displayed in the “Facial rock-paper-scissors” program.

The facial rock-paper-scissors program randomly displays an illustrated image of a face on an Android or iPad tablet. The user performs a response-type rock-paper-scissors game using oral-facial movements to win against the displayed face image. When performing a facial rock-paper-scissors game in a person-to-person mode, changes in the participants’ facial expressions tend to be more subdued, because they feel embarrassed to be seen by their partner, and the effectiveness of mouth and cheek movements decreases. In light of the current situation, in which measures that are in place to prevent the spread of COVID-19 restrict people from opening their mouths without wearing masks in crowded places, the “Facial rock-paper-scissors” program, which can be followed by a single person using a tablet terminal, is likely prove very useful. Rehabilitation for maintenance and improvement of cognitive and swallowing functions can also be performed at medical institutions and facilities with limited numbers of staff, or by the elderly alone at home.

3 Psychological evaluation of the “Facial rock-paper-scissors” program

3.1 Experimental method
In an experiment using the “Facial rock-paper-scissors” program, 72 face images with “rock,” “scissors,” and “paper” expressions were randomly displayed for three seconds each on a MacBook Pro (15-inch screen). Eleven university students (four males and seven females, aged 18 - 23) participated in the experiment. The participants performed the “Facial rock-paper-scissors” program after going through
a preliminary program to practice facial expressions and voicing. The participants were psychologically evaluated before and after the program using the POMS-SF and the TDMS-ST.

In the POMS-SF, which used 30 evaluation items, T-scores by sex and age class were obtained from crude scores on the following six scales: tension-anxiety (T-A), depression-dejection (D), anger-hostility (A-H), vigor (V), fatigue (F), and confusion (C). The TDMS-ST is a psychological scale system used to evaluate levels of vitality, stability, pleasure, and arousal. Eight moods (calm, irritated, lethargic, excited, relaxed, nervous, lazy, and lively) are rated in six grades. The “Level of Vitality” is a measure of the psychological state in which comfortable liveliness and unpleasant calmness are the two extremes; positive scores represent a vivid and active state and negative scores represent a lethargic and inactive state. The “Level of Stability” is a measure of the psychological state in which comfortable calmness and unpleasant liveliness are the two extremes; positive scores represent a relaxed and calm state and negative scores represent an irritated and strained state. The “Level of Pleasure” is a comprehensive measure of the psychological state in which comfortableness and uncomfortableness are the two extremes; positive scores represent a comfortable and positive state and negative scores represent an uncomfortable and negative state. The “Level of Arousal” is a comprehensive measure of the psychological state in which excitement and calmness are the two extremes; positive scores represent an excited and active state and negative scores represent a sleepy and inactive state. The TDMS-ST is suitable for investigating changes in mood between before and after a certain event, and for making rapid evaluations. It can be used to verify the psychological effects of such factors as exercise, living environments, and equipment (Sakairi, Y. et al., 2003).

3.2 Results
In the psychological evaluation using the POMS-SF, the T-scores on the six scales were validated by a one-factor two-level analysis of variance before and after the program. The results showed significant differences before and after the program for “Tension-Anxiety” (F (1,10) = 13.64, p < 0.004), “Depression-Dejection” (F (1,10) = 7.34, p < 0.022), and “Fatigue” (F (1,10) = 7.70, p < 0.020) (Figs. 2-7). This confirms that the “Facial rock-paper-scissors” program significantly improved mood on the scales of “Tension-Anxiety,” “Depression-Dejection,” and “Fatigue.”

***p<.005

Figure 2. Comparison of average T-scores for “Tension-Anxiety” (T-A).

* Error bar: standard error
**Figure 3.** Comparison of average T-scores for “Depression-Dejection” (D)∗.

**Figure 4.** Comparison of average T-scores for “Anger-Hostility” (A-H)∗.

**Figure 5.** Comparison of average T-scores for “Vigor” (V)∗.

* Error bar: standard error
In the psychological evaluation using the TDMS-ST, the scores of the levels of “Vitality”, “Stability”, “Pleasure”, and “Arousal” were examined by one-factor two-level analysis of variance before and after the program. The results showed significant differences in the levels of “Vitality” (F (1, 10) = 21.67, \( p < 0.001 \)), “Pleasure” (F (1, 10) = 18.83, \( p < 0.002 \)), and “Arousal” (F (1, 10) = 7.46, \( p < 0.021 \)). The scores for levels of “Vitality”, “Pleasure”, and “Arousal” were significantly higher after the program (Figs. 8-11).
Figure 9. Comparison of average scores for level of “Stability”.

Figure 10. Comparison of average scores for level of “Pleasure”.

Figure 11. Comparison of average scores for level of “Arousal”.

4 Discussion

With university students as experimental collaborators, changes in mood after implementing the “Facial rock-paper-scissors” program were investigated. The results showed the psychological effects of the “Facial rock-paper-scissors” program to significantly improve subjects’ mood on the scales of “Tension-Anxiety”, “Depression-Dejection”, and “Fatigue” according to the psychological evaluation.

* Error bar: standard error
using POMS-SF. The psychological evaluation using TDMS-ST showed the scores for levels of “Vitality”, “Pleasure”, and “Arousal” to increase significantly after conducting the “Facial rock-paper-scissors” program. In the TDMS-ST, positive scores for level of “Vitality” indicate a state of energetic and vigorous feelings; positive scores for level of “Pleasure” indicate a state of comfortable and positive feelings; and positive scores for level of “Arousal” indicate a state of excited and active feelings (Sakairi, Y. et al., 2003). It can therefore be considered that implementation of the “Facial rock-paper-scissors” program had the psychological effect of making the participants feel energetic, vigorous, comfortable, positive, and active. As a result, the “Facial rock-paper-scissors” program developed in this research, which induces a smiling face, has the psychological effect of improving mood in addition to rehabilitation that maintains and improves swallowing, and cognitive functions. This program can be positioned as a new rehabilitation program aimed at the rehabilitation of swallowing and cognitive functions.

5 Development of a “Facial rock-paper-scissors” program app (patent pending)

Aiming to create a rehabilitation program that maintains and improves cognitive and swallowing functions, the author developed a “Facial rock-paper-scissors” program that incorporates design elements which induce smiling, and confirmed the psychological effect of the program on improving mood. Based on these research results, the author developed an app that allows the program to be performed on a tablet device so that rehabilitation can be performed even at medical institutions and facilities with limited staff numbers, or by the elderly alone at home.

The app contains two types of sessions in the program: one for practice to experience facial expressions and voicing, and the other for practical use. The practice session allows users to understand how to make correct facial expressions and vocalizations for rehabilitation, without assistance from staff. The practical use session has two different stages: the opponent and the “Facial rock-paper-scissors” expressions are fixed in the basic stage (Fig. 1), whereas in the enhanced stage, there are three opponents (a man, a woman, and a child), each with their own facial expressions (Fig. 12). In the stage shown in Fig. 12, each of the three persons is presented with different facial expressions, so the conversion and reconversion processing of stimulus information to form a facial expression that wins against the opponent (based on the recognition of the opponent’s facial expressions as rock, scissors, or paper) is more complex and challenging than in the stage in Fig. 1, where the facial expressions are associated with only one opponent. These stages also come with three graded levels of difficulty that can be matched to the level of cognitive function of the user: making the same facial expression as the illustrated face image; making a facial expression that wins against the illustrated face image; or making a facial expression that loses against the illustrated face image.

On the practical use session’s settings screen, the display time of each image and the time required for practical use can be set to suit the user (Fig. 13). It was also made possible to judge a “win,” “lose,” or “draw” by using the camera function of the tablet to recognize the facial expressions of the user. The final screen presents the score and encourages the user to continue with their rehabilitation efforts by stimulating their aspirations and motivation.
Summary

In this study, we have developed a “Facial rock-paper-scissors” program that provides the psychological effect of improved mood in addition to rehabilitation to maintain and improve swallowing and cognitive functions. In the facial rock-paper-scissors program, mouth and cheek movements and voicing included in swallowing training can be performed as a response-type facial rock-paper-scissors game using oral-facial movements to maintain and improve cognitive function. The program also incorporates a design element that is anticipated to have the beneficial psychological effect of improving mood by making the participants smile while adopting their “scissors” expression.

The results of investigating changes in mood during implementation of the “Facial rock-paper-scissors” program showed that the program significantly improved mood as measured on the POMS-SF scales.
for “Tension-Anxiety”, “Depression-Dejection”, and “Fatigue”. The scores for levels of “Vitality”, “Pleasure”, and “Arousal” on the TDMS-ST scales also increased significantly, confirming the psychological effects of making the participants feel energetic, vigorous, comfortable, positive, and active. These results indicate that the “Facial rock-paper-scissors” program developed in this study provides the psychological benefit of improving mood, in addition to rehabilitation to maintain and improve swallowing and cognitive functions.

Based on these study results, we have developed an app that allows the user to perform the “Facial rock-paper-scissors” program easily using a tablet. The app has a practice session to experience facial expressions and voicing, and a practical use session. The practice session allows users to understand how to make correct facial expressions and vocalizations for rehabilitation without assistance from staff. The practical use session has two stages, so users can select the difficulty level. The first stage has facial expressions by three different opponents but those opponents always perform the same action, that is the “rock” expression is always performed by the same opponent, and so with “paper” and “scissors”. The second stage has three new opponents, not seen in Stage 1, who change their facial expressions randomly between “rock-paper-scissors”. It also allows the “Facial rock-paper-scissors” program to be performed to rehabilitate cognitive and swallowing functions even at medical institutions and facilities with limited staff numbers, or by the elderly alone at home. In the future, the author plans to evaluate the practical application of this program at medical institutions, facilities, and private homes. In addition, we would like to evaluate the program’s effectiveness by comparing face-to-face "Facial rock-paper-scissors" and using the tablet application.

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References


