Motor Action Computer Simulation in Learning Japanese Syllabic Characters: A Training Programme for Mentally Retarded Children to Acquire the Ability to Decode the Syllabic Structure of Words

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Abstract: The research literature notes the importance of mentally retarded children learning to read Japanese syllabic characters (kanamoji) and using "vocal-coordinating motor action" in acquisition of the skill of analyzing the syllabic structure of words (ASSW), which is a key component of reading. This paper examines the effectiveness for mentally retarded children of motor-action simulation on a computer screen to acquire ASSW. Experiment 1 reports on the development of a computerized learning system designed to acquire ASSW using three pre-school aged children with developmental disability. Pre- and post hoc tests were administered to determine ASSW levels. It was found that, despite the youngest subject having difficulty in understanding the nature of the task and attending training sessions out-of-sequence, two subjects improved their ASSW levels. In addition, it was found that a female subject considered unsuitable to attend a conventional training programme using actual "motor action" also significantly improved her ASSW levels using the computerized learning programme. In Experiment 2, the subjects were four physically disabled students with mental retardation. It was found that three subjects improved their levels of ASSW after a brief training session. Videotapes of the training sessions were analyzed to determine whether or not the act of depressing a switch was the equivalent of a "vocal-coordinating motor action." It was found that subjects acquired ASSW without depressing the switch together with vocalization. These results suggest that in the acquisition of ASSW, the use of motor-action computerized simulation is the equivalent of actual motor action.

Key Words: Mental retardation, learning to read, computer screen (2-D display), ASSW (analyzing the syllabic structure of words), simulation

Educators should focus on teaching characters (letters and words) when they teach mentally retarded children to read (Shibazakim, 1985). Resnick and Weaver (1979), and Amano (1985) reviewed both practical and experimental training programmes on initial reading and found that research evidence demonstrated the effectiveness of computerized reading instruction programmes (see Atkinson, 1966; Lally, 1981; Kirkland, 1984). Lally (1981), described for example, the advantages of utilizing a computerized system detailing the consistency of synthesized voice output, the capacity to keep records of learning progress for individualized instruction (Lally, 1981), and Atkinson et al. (1973) examined the effectiveness of providing simultaneous reinforcements and appropriate feedback to learners (Atkinson et al., 1973).

In Japan, Amano (1973) conducted a study of initial reading in mentally retarded children. He successfully developed and trialed a training programme for reading Japanese syllabic characters (kanamoji) through the formation of the action of analyzing the syllabic structure of words (ASSW). Imai (1979, 1983, 1986) and Koyama and Ida (1973) suggested how to use pictographs or verbal familiarization in teaching young children and mentally retarded children to read Japanese syllabic characters. In addition, using Kanamoji-printed wooden blocks (goju-on tsunoki) have been commonly used in the home.

This study reports on the development of computerized learning system based on Amano's training programme on the formation of the action of ASSW. There were two reasons underlying the development of the programme. First, the research design and methodology of the Amano study were considered by the present researcher to be a solid foundation on which to conduct the present study. Second, despite Kobayashi (1971) arguing that the perception of the shape of characters is an important factor in this process it is proposed that this cognitive ability is developed even further in children who have severe difficulty in reading (see Kawai, Inoue & Hara, 1978). Furthermore, the ability to separate a word into syllables is strongly related to reading ability (Kawai et al., 1978).

Amano's training programme aimed to acquire the ASSW by using "vocal coordinating motor action,"
for example, jumping into circles or placing small wooden dolls on a desk at some specified interval and pronouncing a syllable for each doll at the same time. While it is believed that this training programme is effective, it has not been widely used in schools. As a result, it is suggested that a training programme, based on the same theory aimed at the acquisition of ASSW using computers should be developed for use in schools.

Experiment 1: System development and application to children with developmental delay.

The purpose of the experiment was to develop and validate a computerized instruction system for the acquisition of ASSW by mentally retarded children using motor action simulation on a computer screen instead of real motor action. This is based on the hypothesis proposed by Amano (1977) that learning to separate a word into syllables in tasks that demand longer time intervals will not only make the child separate words more precisely, but also cause him to pay voluntary attention to the syllabic components of words.

Hardware Components

Hardware components and the system diagram are described in Figure 1.

Method

Subjects

Biological and medical profiles, levels of ASSW and reading ability levels of subjects are as shown in Table 1. At the time of the experiment, all subjects attended the same private kindergarten in the Tokyo area and were in integrated educational settings. The subjects were tested on the following items:

- Level of rhythmic ability (Amano, 1977): Clapping hands rhythmically coordinating with a series of pulses given every 2-3 seconds.
- Number of acquired Japanese syllabic characters/letters (Kanamoji) (Muraishi & Amano, 1972): Reading of 71 basic Kanamojis, 16 six-syllable words, including special syllables, and four sentences.
- Vocabulary Quotient: Tested using the Language Development test (Gen-go hattatsu kensa).

Components of the Instructional Programme

Step 1

The objective of Step 1 of the programme was to learn to separate a word into words into syllables. The operation required by the learner to complete this task was to be able to touch the screen. The words or materials used in the task were nine two-syllabic words (viz., “ma-ma,” “pa-pa,” “u-ma,” “sa-ru,” “ku-ri,” “mo-mo,” “i-nu,” “ka-me,” and “ta-ko,” and eight three-syllabic words (viz., “o-ma-me,” “o-mi-mi,” “ra-ku-da,” “tsu-ku-e,” “su-i-ka,” “te-re-bi,” “ka-ra-su,” and “to-ke-i.”

a) Use of two or three squares on the screen, the number of squares according to the number of syllables of the word.

![Figure 1: Hardware components and the system diagram](image-url)
Sample routine: After a word was selected from the list, a coloured picture of the word and two or three words were displayed on the screen, the number of squares according to the number of syllables of the word. The system, then, read out the whole word followed by the sound of each syllable in order. When the syllables have finished, a corresponding square is coloured and an icon of a boy (see Figure 2) appeared at the upper side of the coloured square.

Learning Routine: After the sample routine, the icon of the boy reappeared on the first square and started blinking until the learner responded to the system. If the learner touched the monitor anywhere, the system sounded the syllable aloud. At the same time, the instructor asked/guided the learner to vocalize the same sound.

b) Use of a circle on the screen blinking at specific times according to the number of syllables of a word.

Sample routine: A word was selected from the list, then, a coloured picture of the word was displayed and the system read the word aloud. The picture, then, disappeared and was followed by the display of a large circle. The icon of the boy appeared inside the circle. The system, then, sounded each syllable aloud in order. At the same time, the circle filled with a colour.

Learning routine: After the sample routine, the icon of the boy reappeared in the centre of the screen and started blinking until the learner responded to the system. If the learner touched the monitor anywhere, the system sounded the syllable aloud. At the same time, the instructor asked/guided the learner to vocalize the same sound.

Step 2

The objective of Step 2 of the programme was to learn to separate words into syllables fluently. The operation required to complete this task was to push or hit a hand-made 1-switch input device placed on the desk. Words or materials used in this step were the same as for Step 1.

a) To learn how to operate the 1-switch input device.

If the learner pushed or hit the 1-switch device, he/she should know the system would deliver a corresponding response to his/her motor action. The leading aim is to get the learner to use the switch well and to understand how to use this input device as well as learning method.

b) Use of icons designed to have the same appearance as the 1-switch device. The number of icons on the screen is the same as for the number of syllables of the word presented.

Sample Routine: A word was selected from the list, and then a coloured picture of the word and two or three icons were displayed on the screen, the number of icons corresponding to the number of syllables in the word presented. The system then read out the whole word, followed by each syllable in order. When the syllables have been read, the corresponding icon filled with colour and the icon of the boy appeared in the upper side of the coloured-in icon.

Learning routine: After the sample routine, the boy reappeared on the first icon and started blinking until the learner responded to the system. If the learner pushed or hit the switch, the system sounded the syllable aloud. At the same time, the instructor asked/guided the learner to vocalize the same sound.

Step 3

The objective of Step 3 of the programme was to learn to separate words into syllables in the tasks that demanded a longer time interval. The learner was required to push or hit a 1-switch input device placed on the desk. The words used were the same as for Step 1.

a) Motor action simulation on the computer screen:

A boy jumping between two points (see Figure 2).

Sample routine: After a word was selected from the list, a coloured picture of the word and two or three icons were displayed on the screen according to the number of syllables of the word. The system then read the whole word aloud. After that, the picture disappeared. The icon of the boy appeared on the screen and started jumping from left to right, or from the top syllable of the word to the bottom one. The system sounded each syllable aloud in order and at a specified time interval.

The system sounded each syllable aloud in order and at a specified time interval.

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**FIG. 2** Sample of motor acts simulations on a computer screen: A boy is jumping between two points.

Learning routine: After the sample routine, the boy reappeared on the first icon and started jumping from left to right. The time interval was gradually increased. The instructor set the intervals from 0.3
seconds, 1.0 second, and 2.0 seconds. There was no response while the boy was jumping, or in the air, but if the boy reached the next icon and the learner pushed or hits the switch, the system sounded the syllable aloud. At the same time, the instructor asked or guided the learner to vocalize the same sound. This act of vocalization was very important in this routine.

b) Through the act of picking-up the sound of each syllable.

The objective of this task was to learn identify the position of each specific syllabic sound. The learner was required to directly touch the monitor.

Sample routine: After a word was selected from the list, a coloured picture of a word and two or three icons of the device were displayed on the screen, the number of icons corresponding to the number of syllables of the word. The system then read the whole word aloud. After that, the icon of the boy appeared on the screen and started jumping from left to right. The system sounded each word in order.

Learning routine: After the sample routine, the boy reappeared on the first icon and awaited the learner’s response. If the learner touched one of the 1-switch devices on the screen, the boys jumped to the position and the system read the syllable aloud.

Procedure

In the pre- and post tests, ASSW levels were tested using a procedure developed by Amano (1977). Words including “ka-me,” “sa-ru,” “na-su,” “ha-sa-mi,” and “te-re-bi” were used for the trial session. “Wa-ni,” “ku-ri,” “su-i-ka,” “me-ga-ne,” “ma-ku-ra,” “ma-ma,” “pa-pa,” “mo-mo,” “mi-mi,” and “me-me” were used for the clapping hands session. “Wa-ni,” “ku-ri,” “su-i-ka,” “me-ga-ne,” “ma-ku-ra,” “hi-yo-ko,” “ka-ra-su,” “a-hi-ru,” “ra-ku-da” and “ta-nu-ki” were used for the session using paper cards.

The experiment was conducted individually in a small room with his/her home room teacher. The experiment commenced on December 3, 1987 and concluded on December 21, 1987. Steps One, Two and Three were used in order for each subject. Nine to 10 sessions were provided for each subject and ranged from nine to 14 minutes.

Results

Subject (DI) took nine learning sessions during the experiment, session lengths ranging from four to 20 minutes. On the pre-test, he could identify the initial and final phoneme of a word using concrete operations (viz., using a picture board and block), and this corresponds with Amano’s C2 level. After studying a total of 181 words, DI’s level of ASSW increased from a C2 to a C3 level. At the C3 level DI could identify the middle phoneme of a word.

Subject (KT) was unable to improve his ASSW level through the sessions. He could barely separate a word into syllables by means of concrete operations at the post test level (i.e., B2 level).

Subject (KI) took nine learning sessions ranging in duration from six to 32 minutes. At the pre-test level, she was unable to identify any phonemes of a word (i.e., B2 level). After studying 244 words in total, her level of ASSW increased from the B3 level to the C2 level.

Discussion

Due to the school settings, subjects were provided with usual or daily instruction, in addition to these learning sessions. Hence, it should not be concluded that these learning improvements were due to the learning sessions themselves. DI and AI, in turn, had been completing tasks in a sequential way, so that it could be suggested that the system was effective.

Concerning instruction of Subject (KT) who was unable to improve his ASSW ability level, the instructor could not undertake the programme in a sequential manner. This is not only because he was the youngest of the three and was distractable, but...
also the instructor had a problem. To avoid KT's
distractable behaviour such as touching equipment
and devices like the amplifier, PC, microphone, the
frame of the monitor, attachments to the touch
screen, and so on, the instructor attempted to keep
KT's attention by showing him different parts of in-
tructional programmes or gave him feedback. KT
then began to enjoy hearing the voice of the feedback
(e.g., Whenever he received feedback as reinforcement,
such as "You won KT!") he tried to hide himself from
the computer screen. In his case, the feedback did not
make him attend to the learning programme, but
rather, to the feedback itself.

Conclusion

This study reports on the development of a com-
puterized learning system for mentally retarded
children to acquire the act of ASSW. The system was
designed to provide motor action stimulation on the
computer screen. Three developmentally delayed pre-
school children attended the pre-test, learning ses-
sions, and the post test on an individual basis. In the
pre-tests, the researcher explained their ASSW levels
to them. Results demonstrate that the youngest boy
could only understand a little of what the task re-
quired and could not attend his programme in order.
However, two subjects improved their levels of
ASSW. As a result, it is suggested that the developed
system is effective.

Experiment 2: Effectiveness of the use of motor ac-
tion simulation on a computer screen for mentally
retarded children with a physical disability

| Table 2 | Biological and medical profiles, and reading abilities of the subjects in Experiment 2 |
|-----------------------------------------------|
| Subject | A.T. | K.W. | R.O. | Y.T. |
| Sex | M | F | F | F |
| C.A. | 12:4 | 7:0 | 7:3 | 15:4 |
| I.Q. | 25 | 48 | 56 | 33 |
| Medical Diagnosis | Cerebral Palsy | Spina Bifida, Hydrocephalus | Cerebral Palsy | Cerebral Palsy |
| Disorders of articulation | (+) | (-) | (-) | (+) |
| Number of Acquired Letters | 0 | 0 | 0 | 42 |
| Vocabulary Quotient | — | 43 | 44 | — |

Note: Each of the Names and dates of the conducted I.Q. tests were for A.T. (Tanaka-Biro, 1991.5.23); K.W. (Tanaka-Biro, 1991.9.2); Y.T. (Owaki 1988.6.12). Vocabulary Quotient was based on Language Development Test (Genô hattatâu kensa) and the score of A.T. was under 20 and Y.T. could not attend the test.

It is obvious that the majority of physically dis-
abled children cannot attend to the reading
programme using "vocal-coordinating motor action,"
even if this proves to be effective. Consequently, it
was considered important to examine the effective-
ness of the programme used in Experiment 1 for
mentally retarded children who have difficulty per-
forming "real" motor action. This finding had been
supported by the results from Experiment 1 that in-
dicated that a girl with hemiplegia had improved her
ASSW levels significantly by using the computerized
learning programme. The purpose of Experiment 2
was, therefore, to examine the effectiveness of the
use of motor action simulation on a computer screen
for mentally retarded children with physical disabil-
ity.

Method

Subjects

Biological and medical profiles and reading abilities
are shown in Table 2. These subjects had not ac-
quired ASSW. They could name picture cards aloud,
use a wheelchair, and it would not be possible to ac-
quire ASSW by means of motor action.

Individual instruction took place in the Speech
Therapy Room at subjects' school from October 5,
1991 to October 12, 1991. One to four sessions were
given to each subject and the average duration of
each session was 16 minutes.

The researcher took a instructors rol in the ses-
sions (accompanied homeroom teacher if necessary).
The apparatus used in Experiment 2 was basically
the same as for Experiment 1 with specific adapta-
tions for the individual requirements of subjects in terms of input devices, display
unit, and other materials. For example, a
switch was adapted to a flat type of switch.
In terms of materials, KW and RO used the
same materials, and owing to AT's limited
vocabulary and difficulty in looking at pic-
ture cards, different materials were prepared
and used. Digital photographs were taken of
familiar teachers and his friends and their
names were added to the word list. They
were "Ki-mu-ra," "Ta-ke-ya," "O-gi-no," "Na-
o-ya," "Na-gu-no," and "Ma-sa-shi." For fu-
ture learning, words of digital pictures
which had been developed and kept at his
school were also added to the list. These
words were "su-i-ka," "to-ma-to," "ba-na-na,"
"ha-sa-mi," "me-ga-ne," and "te-re-bi." The
voice of his homeroom teacher was recorded and used in the presentation and motor action simulation was the same as for Experiment 1.

Results

Subject YT had great difficulty learning with the system, especially in the operation of the input device. In addition, the researcher could not use the same strategy to examine her level of ASSW.

Subject AT was unable to separate simple two syllabic words such as "pa-pa" and "ma-ma" in his pretest (< A1 level). After four learning sessions, he attained the A2 level (i.e., he could distinguish more complex two syllabic words and some three syllabic words). The duration of sessions ranged from 11-30 minutes and 151 words were used during the sessions.

Subject KT could distinguish two syllabic words in her pre-test (A2 level), and after four training sessions, achieved the B2 level. (i.e., She could separate three syllabic words and identify each phoneme of two syllabic words using her index finger). The duration of sessions ranged from eight to 16 minutes and 176 words were used during the sessions.

Subject RO could separate two syllabic words in her pre-test (A2 levels) and after three sessions, she reached the A3 level (i.e., she could separate three syllabic words).

Discussion

In this learning programme, subjects were asked to depress a switch with vocalization of a phoneme to assist the learner to actively engage in his learning programme. However, the action of depressing the switch itself was problematic in that could it be considered as the equivalent of a "vocal-coordination motor action," even though this fine motor movement was small in comparison with the gross motor action of jumping as in the conventional programme. The researcher re-evaluated the records of all sessions and found that AT had the tendency to vocalize as he depressed the switch. Subjects KW and RO depressed the switch many times at a vocalization act and their action seemed to imply that they were trying to move the picture of the boy forward, or move on in the programme itself. These observations suggest that subjects could improve their ASSW abilities, not only through the use of small amounts of "vocal coordinating motor action" compared with jumping, but also without "vocal coordinating motor action."

The system was equipped with a commercial AD-DA voice input and output board (Sampling rate = 6KHz), so that voice quality was not very good. To overcome this the instructor enunciated any unclear words that emanated from the system. As a result, it is suggested that any poor voice quality would not have affected the learning. This assumption was, however, tested. Each voice was presented to individually to subjects. First, a word was presented, and then each of its phonemes was presented in order. Subjects made no mistakes. Second, subjects were presented with a word, and then each phoneme of the word was presented in reverse order. Subjects made four mistakes (viz. /ba/mi/re/ and /bi/ of the 17 phonemes).

While these results revealed a weakness of the system, for Subject (KT), the test was conducted during the mid-period of her learning session and her results revealed that awareness of phonemes was established at the mid-period of her learning session.

Conclusion

As described above, three of the four subjects in this study improved their ASSW levels following the learning sessions, even though the sessions were relatively brief. For YT, who was unable to improve her skills, she had only one learning session and used 36 words, because of the deficiency of the input device. These results suggest that the use of motor action simulation on a computer screen is the equivalent of the use of real motor action, at least in the acquisition of the act of ASSW in mentally retarded children with physical disabilities.

General Discussion

Although the researcher was aware that it would be better to prepare both a control and experimental group to evaluate the effectiveness of the learning programme, he was unable to prepare a control group in the experiments described above. However, because both experiments were conducted separately and a wide time interval, the results were positive, suggesting that the system was effective.

Amano (1977) reports that it was very difficult for mentally retarded children to acquire ASSW without "vocal-coordination motor action." He conducted the training programme using the action and had a positive outcome. The results of the present study suggest that the use of motor action simulation on a computer screen is the equivalent of the use of real motor action, at least in the acquisition of the act of ASSW. This is extremely important for mentally
retarded children with physical disabilities (e.g., the subjects used in Experiment 1), because they were unable to participate in a conventional programme using real motor action.

Future Research Issues

This paper found that the use of motor action simulation on a computer screen is the equivalent of the use of real motor action, at least in the acquisition of the act of ASSW. However, factors related to, and the mechanism of the learning process itself was not revealed. Owing to the fact that there are many mentally retarded children who have difficulty in performing motor action, the conducting of an effectiveness study on the use of motor action simulation using a computer in various other learning areas is suggested.

Research in the field of virtual reality investigates simulation of human motor action and sensory behaviour in a “virtual environment”. In this research field, advanced computer simulation is used (e.g., the creation of a virtual 3-D space). While on the one hand, the findings of the present study contribute some information to this field, on the other the use of advanced technologies should be used to develop more effective instructional systems.

References


