An electronic aid for practising letter-sound relations

Instituut voor Perceptie Onderzoek
Postbus 513, 5600 MB Eindhoven

PR/pr 86/39
16.04.1986

Manuscript no. 540

An electronic aid for practising letter-sound relations

P. Reitsma, H.H. Ellermann
and G.W.G. Spaai

T.b.s.t.: EURIT 86, European conference on information technology
in education, May 20-23, 1986, Enschede, the Netherlands

AN ELECTRONIC AID FOR PRACTISING LETTER-SOUND RELATIONS°

P. Reitsma*'**, H.H. Ellermann* and G.W.G. Spaai*

*Institute for Perception Research, P.O.Box 513, Eindhoven, The Netherlands
**Paedologisch Instituut, Amsterdam, The Netherlands

ABSTRACT

A computer-based prototype system with which beginning readers can practice the correspondences between letters and sounds is described. Both the choice of hardware components (i.e. digital speech output, touch-input) and the design of the software is discussed. Some preliminary results of field tests are presented and future developments are discussed.

KEYWORDS

CAI for beginning readers; interactive learning; touch input; synthetic speech

INTRODUCTION

It is generally acknowledged that learning how graphemes map onto phonemes is an important component of learning to read. Although the knowledge of letter-sound correspondences does not by itself guarantee competent reading behaviour, it is considered to be important for learning to read alphabetical writing. Letter sound knowledge by itself may not be sufficient to move a child into effective printed word learning, but the task to process and remember correspondences between pronunciations and spellings may be facilitated significantly if pupils possess letter sound knowledge (Samuels, 1972). Ensuring that a child learns about these correspondences seems therefore to be a worthwhile instructional objective. Most curricula for teaching initial reading in The Netherlands emphasize learning the letter-sound correspondences. In order to achieve fluency in associating letters and sounds, there is often need for extended practice and instruction, especially for low-achieving pupils. The time available for reading instruction and teacher-directed practice is, however, for practical reasons necessarily limited. As a solution for this problem, the present paper explores the possibilities of a computer-based system for providing relatively independent practice in associating letters and sounds.

°The research reported here is supported by funds of the Netherlands Ministry of Education and Science.

SPECIAL REQUIREMENTS FOR OUTPUT AND INPUT

Under what conditions can computers be incorporated into the process of teaching children to read? Considering the small microcomputer systems most popular in schools today, the answer to this question will probably be "none". The microcomputers readily available are not well adapted for this purpose. Most important caveats are: poor-quality screen characters, no audio output capability, and only keyboard input. Our solutions to these three problems are:

1. The video screen normally displays its output in dot matrix form. The small matrix characters are often difficult to read, especially for novice readers. In most cases, a solution to this problem requires no additional hardware. Using software capabilities for bit mapped graphics, it is possible to enlarge the letters and to create clear and distinct forms. In our application an alphabet was created that closely resembles the type font children are confronted with in their books at school. Figure 1 shows some examples of the enlarged character set compared to the standard screen output on a 9 inch monitor. While in the micro used here (Hewlett Packard HP-150) letters are normally presented in matrices of 7 by 10 pixels, in the new font type the character width varied from 16 (i) to 71 (m) pixels, and height varied from 39 to 65 dots.

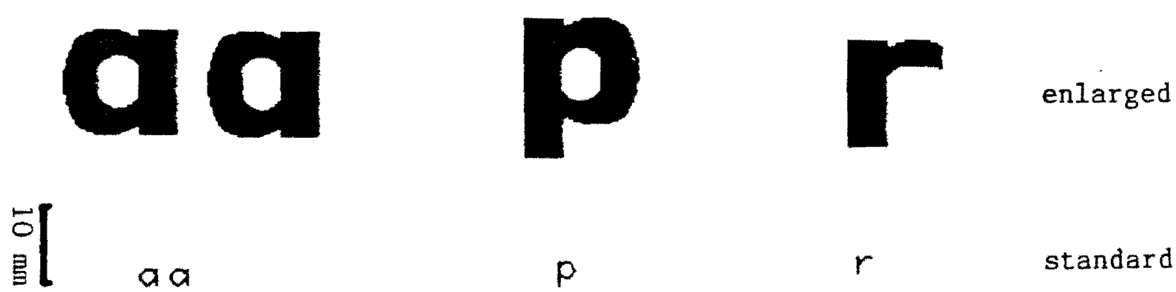

Fig. 1. Some examples of the enlarged and standard character set.

2. A program for practising letter-sound relations will most often be used by pupils who are not yet able to read, and screen-based instruction should therefore be avoided. In particular, children who have trouble in reading may not easily be able to understand instructions presented via screen messages. Voice output seems to be a necessary alternative to the standard video screen in CAI applications for beginning readers. The feasability of introducing voice technology in educational software has recently increased rapidly. A variety of possible forms of voice output are now easily and cheaply available. Methods vary in terms of storage requirements, complexity of coding and decoding, and quality of reproduced speech. The choice of speech storage and reproduction techniques obviously depends on the requirements of a particular application. If storage volume is limited and no high quality of speech is needed, a flexible rule-driven text-to-speech synthesizer might be a good solution. In case of fairly predictable and lenghty messages an inferior speech quality is often adequate. If, however, inexperienced listeners are involved, and the fine details of the message are important, a higher quality of speech is required. Voice synthesized from prerecorded digitized speech can be quite high in quality, but intelligibility strongly depends on the technique of coding. One way of achieving compact coding of speech is by using Linear Predictive Coding (LPC). In LPC, digitized speech is converted to a limited set of relevant speech parameters. In order to regenerate speech, these parameters are sent to a synthesizer. In general, LPC can offer quite acceptable and intelligible speech, especially when speech sounds are presented in context-giving sentences. It was therefore decided that in the particular application of a system for practising letter-sound associations, all instructional and evaluative sentences could ad-

equately be presented using LPC. Eighteen different instructions were recorded and analyzed with the IPO speech analysis and resynthesis system (Vogten, 1985). The storage requirements for these sentences (about 38 sec in real-time) were about 10 kbytes in total. These speech data were used for controlling the Philips speech synthesizer MEA8000 whenever during the interactive program some message or a comment was needed (some examples are given later). In preliminary research on the intelligibility of utterances presented in isolation to 6, and 7-year-old children, we found that for isolated sounds a very high quality speech reproduction is required. To obtain clearly intelligible letter-sounds a straightforward digitising of the speech signal should be used, with no compression at all. Fifty letter sounds (including some dialectic variants) were recorded, sampled at 10 kHz, digitized through a 12-bit ADC, converted to 8-bit data, and programmed into 32-Kbyte EPROMs. The letter sounds could be played back in real time at 10 kHz through a 8-bit Digital Analog Converter.

3. If children cannot read well, they probably cannot type well too. Therefore if possible, the keyboard as an input device should be bypassed. We would have liked to allow the pupil to respond by simply speaking. Unfortunately, speech-recognition technology is not sufficiently advanced for this to be a practical solution. Alternative input devices, such as a light-pen, a paddle, a mouse, or a touch-screen, can also eliminate the need for using a keyboard. Pilot work in our laboratory indicated that a touch screen would be preferred by young children, enabling them easy access to the computer. Obviously, pointing is a very natural way of selection. In the application described here, a HP-150 microcomputer was used, which has a touch screen fully integrated with the system. Infrared light beams form a matrix across the face of the monitor. When the screen is touched, the light beams are broken and the X-Y coordinates of that interruption are used to determine the position of the finger on the screen. A touch screen permits children to make a direct selection of the alternative answers presented on screen.

COURSEWARE REQUIREMENTS

Within the instructional domain of initial reading, it is not likely that the computer will ever be used for delivery of complete curricula. Instead, modern technology can provide instructional tools to support a teacher-directed curriculum. Initial introduction and specific tutorial instruction will probably be given by the teacher her or himself. An electronic aid for practising letter-sound associations should therefore be designed to be supplementary to regular teaching activities. As in the Stanford reading curricula (Fletcher, 1979), the primary objective of the present program was not to impart new knowledge, but to present beginning readers an opportunity to practice extensively using material they have already encountered, i.e. to further develop accuracy and proficiency in the skill of matching letters and sounds already introduced. The selection and ordering of letters and letterclusters was for this reason directly related to the content of the reading method used in the classrooms (Caesar, 1980). In Table 1 the 36 letters (clusters) that are successively treated in the program, are listed with their corresponding phonemic values. The teacher was allowed to (de)limit the set of letters to be practised according to progress in classroom instructions.
Next to the requirement of compatibility of learning material with the regular curriculum was the requirement to free the teacher of constant supervision of individual children working with the computer. Hence, the system should allow that a child works independently with the computer and should enable the student to engage in an interactive learning environment without the constant presence, assistance, and encouragement of the teacher. In the software design, therefore, care was taken that at all appropriate moments the computer would

TABLF 1   The Letter-Sound Associations Used in the Program.

1	*r*	/r/	7	*b*	/b/	13	*i*	/ɪ/	19	*z*	/z/	25	*h*	/h/	31	*ou*	/ɑu/
2	*s*	/s/	8	*v*	/v/	14	*g*	/X/	20	*o*	/ɔ/	26	*j*	/j/	32	*sch*	/sX/
3	*m*	/m/	9	*k*	/k/	15	*w*	/ʋ/	21	*a*	/ɑ/	27	*ij*	/ɛi/	33	*eu*	/ɸ/
4	*l*	/l/	10	*aa*	/a/	16	*u*	/œ/	22	*ie*	/i/	28	*oe*	/u/	34	*ei*	/ɛi/
5	*p*	/p/	11	*oo*	/o/	17	*e*	/ɛ/	23	*n*	/n/	29	*ui*	/ʌy/	35	*au*	/ɑu/
6	*t*	/t/	12	*ee*	/e/	18	*d*	/d/	24	*f*	/f/	30	*uu*	/y/	36	*ch*	/X/

tell the pupil what to do by giving instructions and evaluative feedback. Moreover, since the spoken instructions were delivered by earphones, the interactions were individualized and did not interrupt other classroom activities. The 18 different spoken directives and comments were resynthesized whenever needed or appropriate during the practice sesions. An individual session could be started by inserting a personal 3.5" microdisc in the discdrive and pointing to a sketch of a door drawn at the screen (audio was available too: "If you want to start, then point to the door"). The general format of the learning procedure consists of the presentation of 5 or 7 letters at (pseudo-)random positions on the screen and asking the child to point to one of them (e.g. "Point to the ... /r/"). This request is available in three versions to avoid monotony. When the pupil points to a position of the screen where no letter-(cluster) is drawn, a warning follows accordingly ("There is nothing here"). If the correct letter is selected a confirmative comment is given ("Correct" or "You've done well") and the lettersound is repeated ("This is a ... /r/"). If the pupil makes an error, the comment is: "No, this is a ... /m/" (again in several versions). Thus, in all cases the system provides adequate feedback immediately after the child makes a pointing response. After a short pause, the next trial starts with the presentation of a new set of letters and asking for selection of another letter. During one session a maximum of 60 consecutive trials for one student is possible. By keeping extensive records of individual performance (saved on personal discs), it was possible to construct a model of what each student knows and to make instructional decisions based on students responses. According to the view that letters less well known should get more practice, at any given point the letter-sound association to be practiced (target letter) could be selected on basis of previous performance. Similarly, in order to prevent frustration and to maintain good temper, if a pupil makes a number of errors in succession a target is presented which is very likely to be responded to correctly as indicated by past performances. When a given selection of letter-sound relations is fully mastered, as should be determined by examining performance data, the program can automatically move to a next set of letters, or end the session. A session also stops automatically when three errors are made in succession or when no response is given on four consecutive trials. Teachers were allowed to break the session any time.

In order to determine which target letter should be presented and whether a mastery criterion is reached for a given letter-sound relation, a simple parameter was computed. For a given learner this parameter was calculated for each letter and updated after a trial was completed. The learning criterion parameter was based on a revised "incremental learning model": this parameter is increased by a constant amount for each correct answer, but reduced by a constant when an error occurs. It was possible by the teacher to obtain for each child a list of learning parameters for each pair of letter and sound (ranging from 0.0 to 1.0). Teachers were explained that an arbitrary chosen value of 0.8 could be taken to be the mastery criterion. Thus, teachers were allowed to check individual performances at any time. In order to further facilitate integration of the use of this practice program within the regular teaching activities, teachers were also permitted to predetermine the range of letters to be practised for each student and make changes whenever they feel it to be beneficial for that particular pupil.

SOME PRELIMINARY RESULTS AND DISCUSSION

No data are yet available to determine the overall effectiveness of this newly developed educational aid. Nevertheless, results of preliminary field tests indicate that the basic concept is valid and promising. Both children, a total number of 81 beginning readers from three different elementary schools did use the apparatus for several weeks, and the teachers were rather enthusiastic. Perhaps the most frequent positive comment was the possibility to practice independently. During the two or three sessions in which they participated, all children really enjoyed working with this electronic aid. Although first experiences indicate that the present system, using speech output and immediate feedback, tends to be intrinsically motivating, it remains to be seen whether this would be maintained in everyday classroom situations.

At least two relatively unique aspects of the system deserve some discussion. Firstly, a touch-screen as an easy-to-use alternative to the traditional keyboard seem to exhibite a number of advantages. Indeed, without any further instruction, all children immediately understood that they could use their forefinger to make their choices. They seemed to like this direct way of interaction very much. One might ask how accurate children can manually designate points on a display or whether there are directional response biases in touch-input. Such information may be important for formatting input-areas in future work. Of course, the present task does not require relatively high resolution. The display area of each character was at least as large as children's fingertip. Moreover, the touch-sensitive area was programmed for each letter separately and includes extra space on all sides. In these conditions, it was found that of a total of 7,183 responses only 2.7 percent pointing errors occurred. The number of times children pointed to an area where no letter was displayed is negligible. Further analysis of the data revealed that generally the subjects touched right at the centre of the displayed letter(-cluster). Only a slight tendency was found to point at the upper left of the centre. No effects were found of relative position of the targets on the screen. In sum, since it requires no training or experience at all and error rate could easily be kept rather low by judiciously spacing items and touch-sensitive areas, it should be concluded that a touch screen is a preferable device for young children to indicate their choices.

Secondly, the children unanimously and vociferously appreciated the fact that instructions and comments were spoken to them by the apparatus. The synthesized sentences or messages appeared to be all quite intelligible; no misunderstandings or complaints about quality were reported. As far as messages are of reasonable length and are fairly predictable, coded speech regenerated by a computer seems to be quite suitable for use with CAI. Although they were digitized without data compression in order to obtain high quality of speech, the sounds of letters appeared to cause some trouble. The overall frequency of confusions was about 5 per cent. Especially some consonant phonemes were apparently hard for the computer to reproduce faithfully and also hard for the children to distinguish. Since at a given trial nontarget letters were randomly selected irrespective of their similarity to the target lettersound, unfortunately no balanced confusion matrix could be constructed. Tabulation of confusions, however, clearly indicated that /p/, /t/, and /b/, and /t/, /f/ and /s/ are among the sounds that are difficult to distinguish. These phonemes, of course, differ only by one or few distinctive features and are often hard to distinguish in natural speech too, at least when presented in isolation. In instructing young children about symbol-sound correspondences, teachers often make deliberate use of mouthing cues to demonstrate differences between sounds. It is obviously rather difficult to provide such articulatory prompts by a computer system. Solutions therefore may in future developments be sought in further improving sound quality e.g. by using advanced high fidelity audio apparatus, like the compact disc technology. One may alternatively choose to constrain the nontarget letterset to letters that differ widely from the target. The opportunity to practice in discriminating subtle sound differences remain somewhat limited if distractors need to differ maximally from the target letter. Nevertheless, numerous letter-sound correspondences could well be practised with the aid of a 'talking computer' without additional cueing or prompting of small phonemic features.

Further research is planned in the near future in order to improve the present design. Several improvements are necessary, but at the moment sufficient knowledge is lacking about some relevant aspects. Within the domain of learning a limited set of letter-sound correspondences, there seems to be a genuine opportunity to further develop and refine a response sensitive target selection strategy. Selection of letters to be practised should be optimally based on inferences about an underlying model of the learning process and information about each pupil's response history. Furthermore, since the effect of different feedback procedures is likely to be specific for a given task, various ways of providing instructional feedback during practice in associating letters and sounds should be explored (e.g. Kulhavy, 1977). Also, although some preliminary notions have already been documented here, considerably more should be done to identify appropriate specifications for classroom implementation and curriculum integration. The results so far, do strongly support the conclusion that further improvements and extensions could well make the electronic aid for practising letter-sound relations a truly powerful educational tool.

ACKNOWLEDGEMENT

The authors would like to express their gratitude to Dr.D.G.Bouwhuis for his support, to J.A.van der Linden, J.Tiesinga, N.Nissink, M.Kösters, M.Bartelds, and H.van der Griendt for their technical help and assistance in various phases of this project, and the Principals, staff, and pupils of elementary schools Genderdal, Klimop, and Springplank for their kind cooperation.

REFERENCES

Caesar, F.B. (1980). Veilig leren lezen. Tilburg: Zwijsen.
Fletcher, J.D. (1979). In Resnick, L.B. and Weaver, P.A. (Ed.), Theory and practice of early reading, vol.2, Hillsdale, L.Erlbaum.
Kulhavy, R.W. (1977). Review Educ.Research, 47, 211-232.
Samuels, S.J. (1972). American Educ. Research Journal, 9, 64-74.
Vogten, L.L.M. (1985). LVS - Speech processing programs on IPO-VAX 11/780, Internal IPO Report, nr. 67, Eindhoven.