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Effects of Repeating Back Instructions on Accuracy in Following Them

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ABSTRACT

In an experiment simulating communication between air traffic controllers and pilots, subjects were given navigation instructions varying in length telling them to move in a space represented by grids on a computer screen. The subjects followed the instructions by clicking on the grids in the locations specified. Half of the subjects read the instructions, and half heard them. Half of the subjects in each modality condition repeated back the instructions before following them, and half did not. Performance was worse for the visual than for the auditory modality on the longer messages. Repetition of the instructions generally depressed performance, especially with the longer messages, which required more output than did the shorter messages, and especially with the visual modality, in which phonological recoding from the visual input to the spoken output was necessary. These results are explained in terms of the degrading effects of output interference on memory for instructions.

BACKGROUND

We have been studying cognitive limitations on comprehension of navigation instructions in a specific concrete domain, namely messages from air traffic controllers to pilots. Previously, we developed an experimental paradigm analogous to the natural flight situation (Barshi, 1997, 1998; Barshi & Healy, 1998). In our laboratory task, subjects receive and follow directions like those given by air traffic controllers, navigating in a space on a computer screen. The space consists of a grid of four 4 X 4 matrices stacked one on top of another to simulate three-dimensions. Subjects use the computer mouse to follow the instructions, clicking each appropriate square on the grid in the order specified (see the sample screen).

In air traffic control, messages are usually presented in the auditory modality, but through "data link" the visual modality is sometimes used instead. In the present study, we compared the comprehension of messages presented visually and auditorily. Pilots are required to repeat, or readback, the directions given to them by air traffic controllers. Hence, in this study, we also investigated the role of repeating directions aloud on the execution of these directions.

METHOD

As in our previous studies (Barshi, 1997, 1998; Barshi & Healy, 1998), subjects were given messages of 6 different lengths, ranging from 1 to 6 commands, with the commands varying in their wordiness. The commands either included redundant four-word statements (e.g., "turn left two squares") or they included minimal two-word statements (e.g., "left two"). In the auditory condition, subjects heard the messages played by the computer, whereas in the visual condition, they saw them presented down the side of the computer screen with one word on each line. All the words in the message were presented simultaneously in the visual condition with the duration of the visual display matched to the duration of the auditory presentation in the auditory condition. Subjects in each condition were given 72 messages arranged in 6 blocks of trials, with 2 messages of each length in each block, 1 message at each level of wordiness. The subjects in each condition were subdivided into two groups. The readback group repeated aloud the directions before following them, whereas the no-readback group did not. We tested 48 subjects in this experiment, all of whom were college students and native speakers of English.

Sample Screen with a Three-Command Message
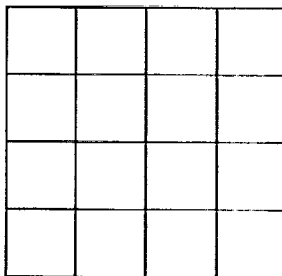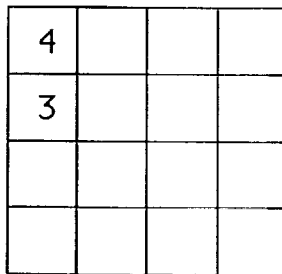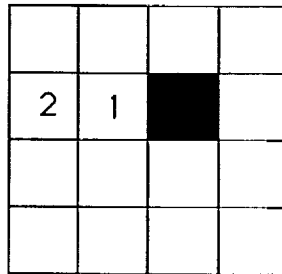## Showing the Required Steps
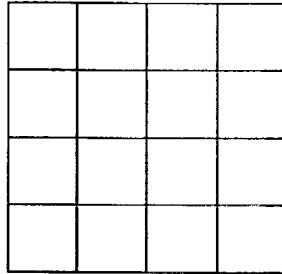
Instructions:

Turn left two squares
(1,2)

Climb down one level
(3)

Move forward one step
(4)

Done

DESIGN

Independent Variables

Between-Subjects Variables

Modality (auditory, visual)

Repetition (readback, no readback)

Within-Subjects Variables

Trial Block (1-6)

Message Length (1-6 commands)
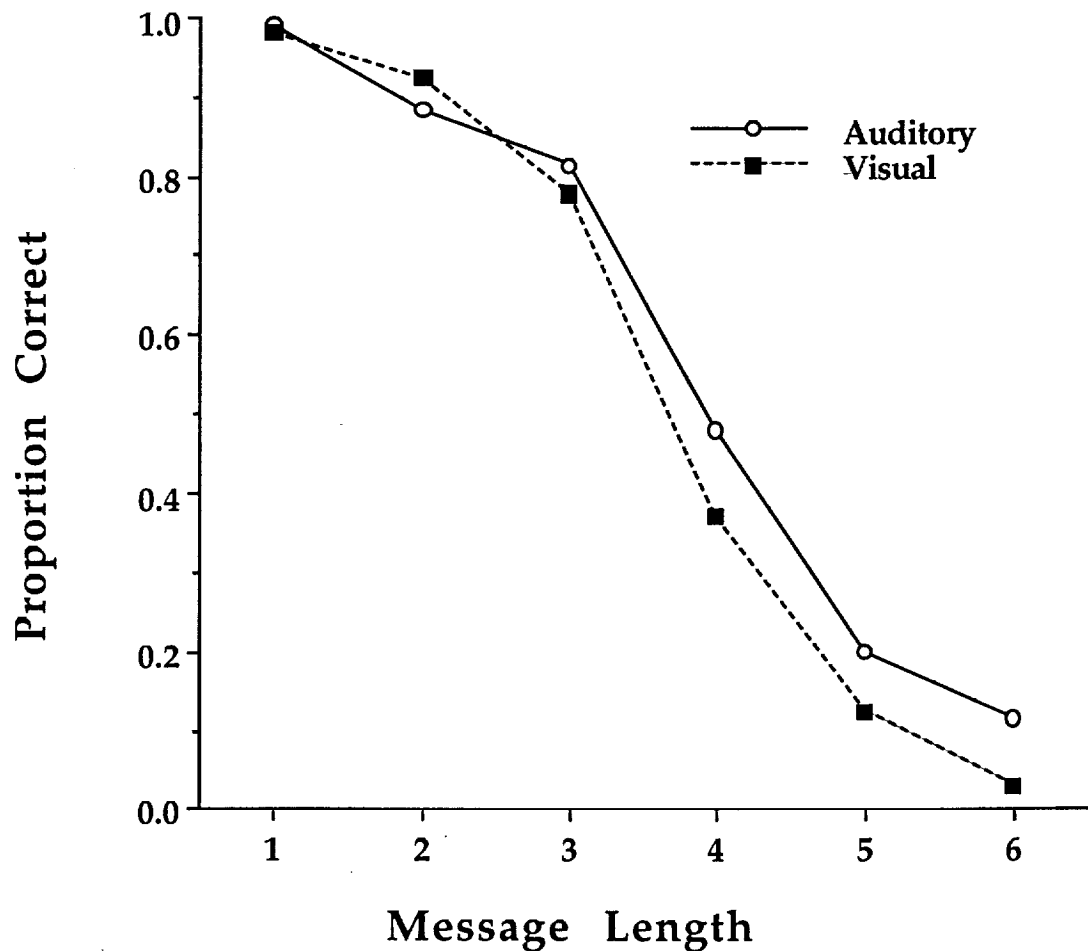
Wordiness (minimal, redundant)

Dependent Variable

Accuracy in Following Directions (manual movement responses scored either as completely correct or as incorrect)

As found previously (Barshi, 1997, 1998; Barshi & Healy, 1998), accuracy decreased monotonically with increases in message length, with the greatest drop between Lengths 3 and 4. There was no overall effect of wordiness. Doubling the number of commands severely lowered performance, but doubling the number of words in each command had little effect. However, wordiness interacted with message length; minimal messages showed better performance than redundant messages at message Lengths 3 and 4.
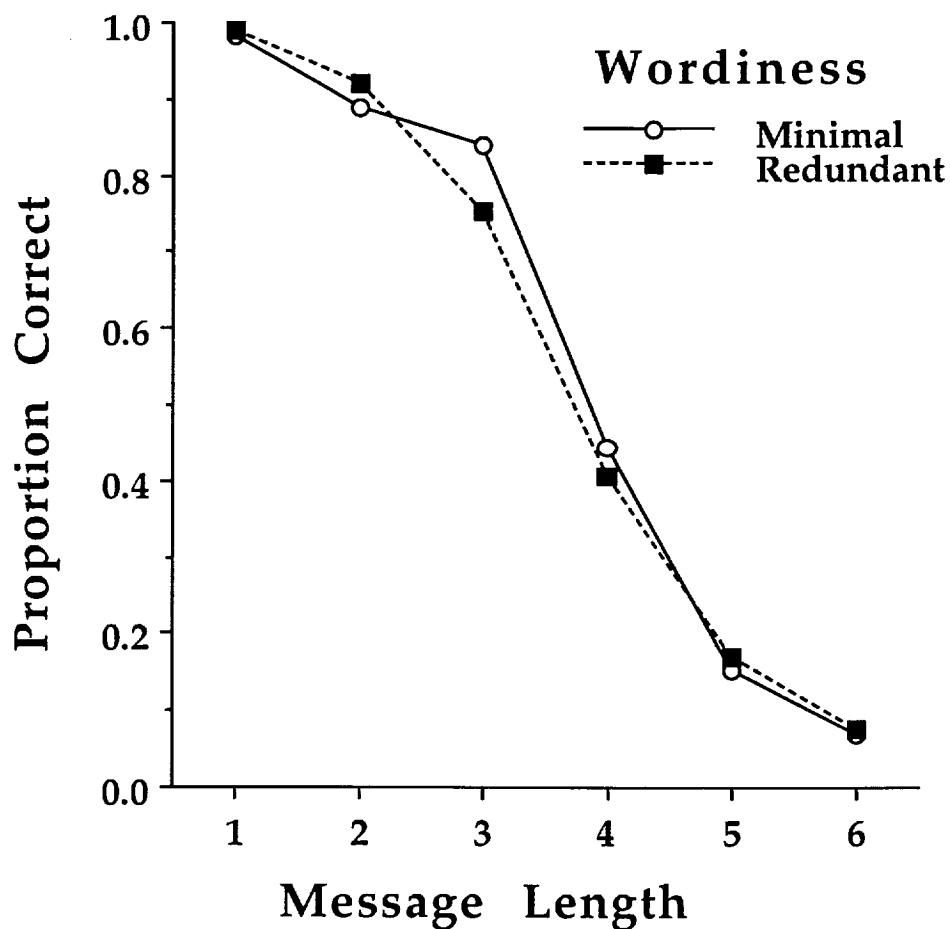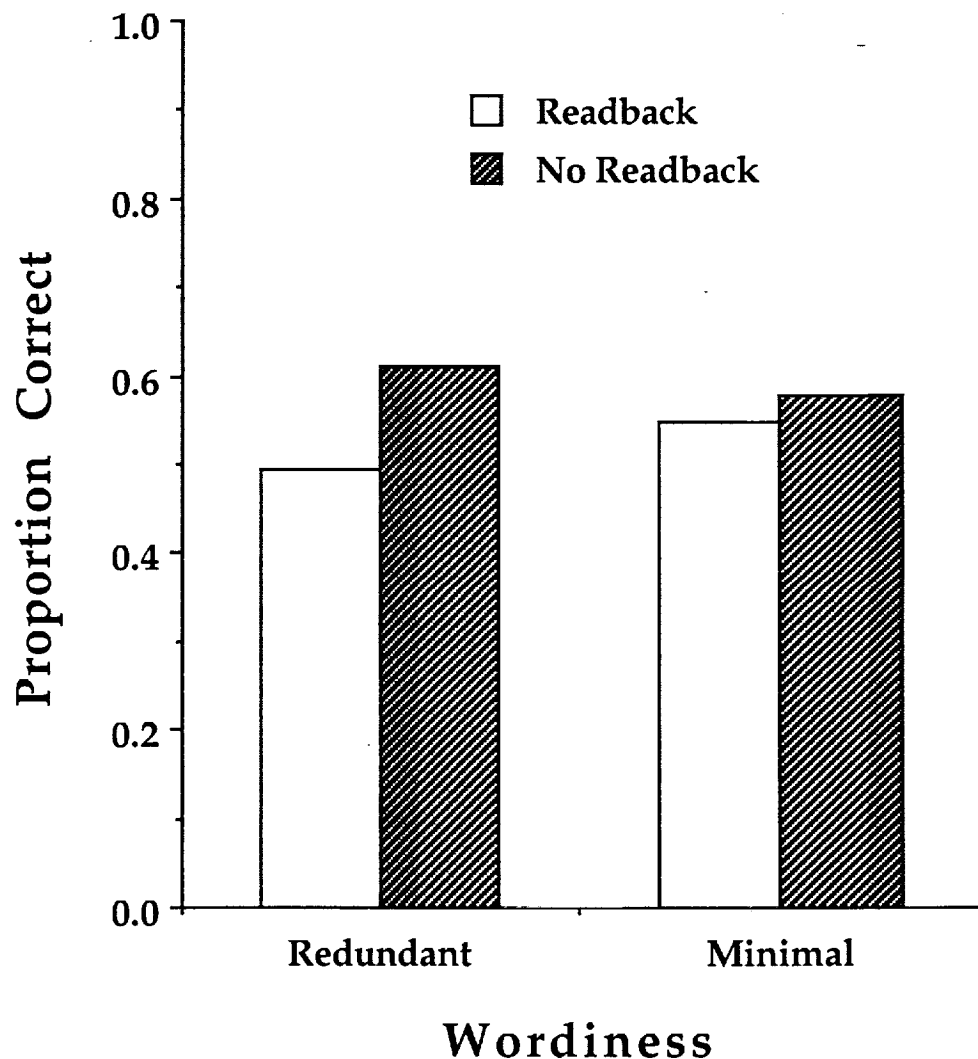
Overall accuracy with the visual modality tended to be worse than with the auditory modality. There was an interaction of modality and message length. The disadvantage for the visual modality was greatest at the longest message lengths.

The effect of modality on accuracy was also qualified by wordiness. The advantage for the auditory modality was much larger for the redundant messages than for the minimal messages.
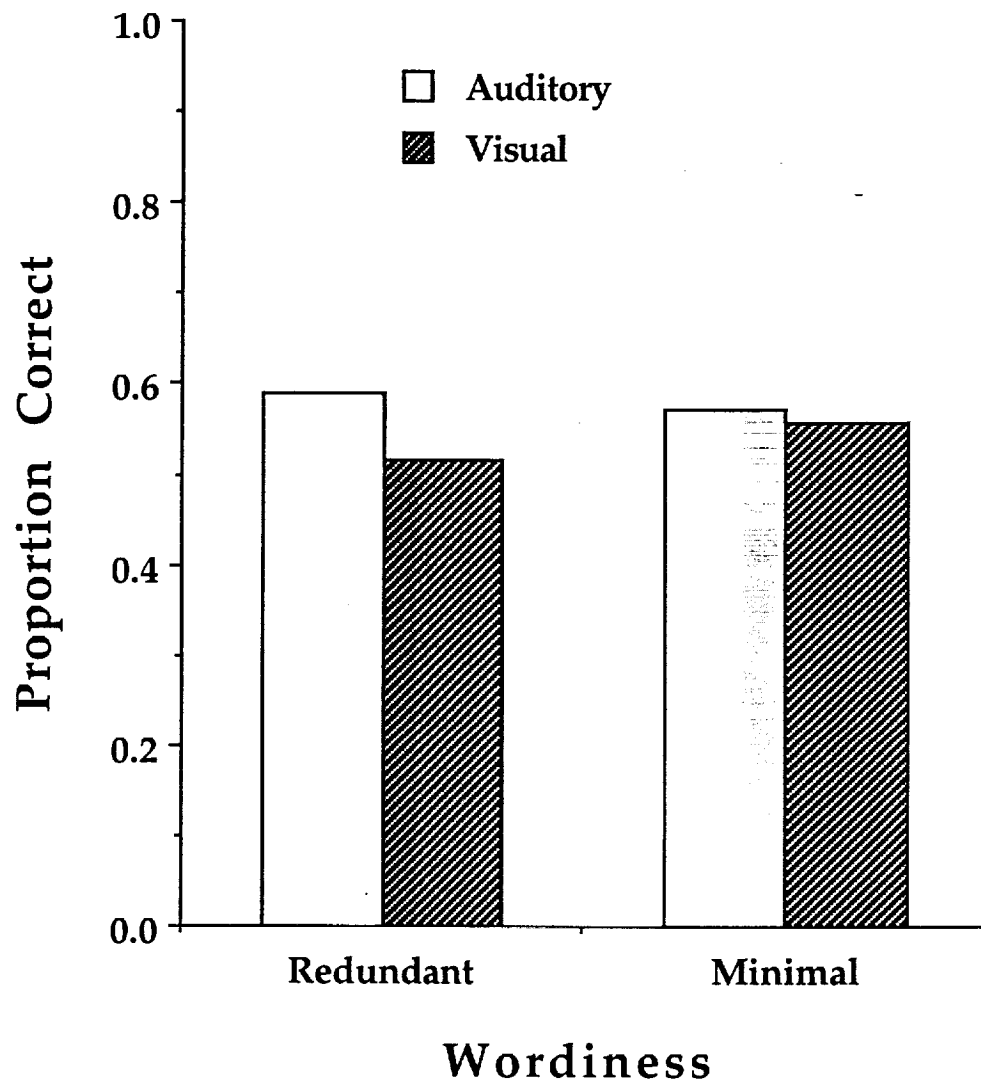
Readback had an overall impact on performance. Subjects in the readback condition were less accurate on average than those in the no-readback condition. However, the effect of readback depended on wordiness, because the disadvantage of readback was much larger for the redundant messages than for the minimal messages.

The effect of readback on accuracy also depended on message length, because the disadvantage of readback was evident only at message Lengths 3 to 6.
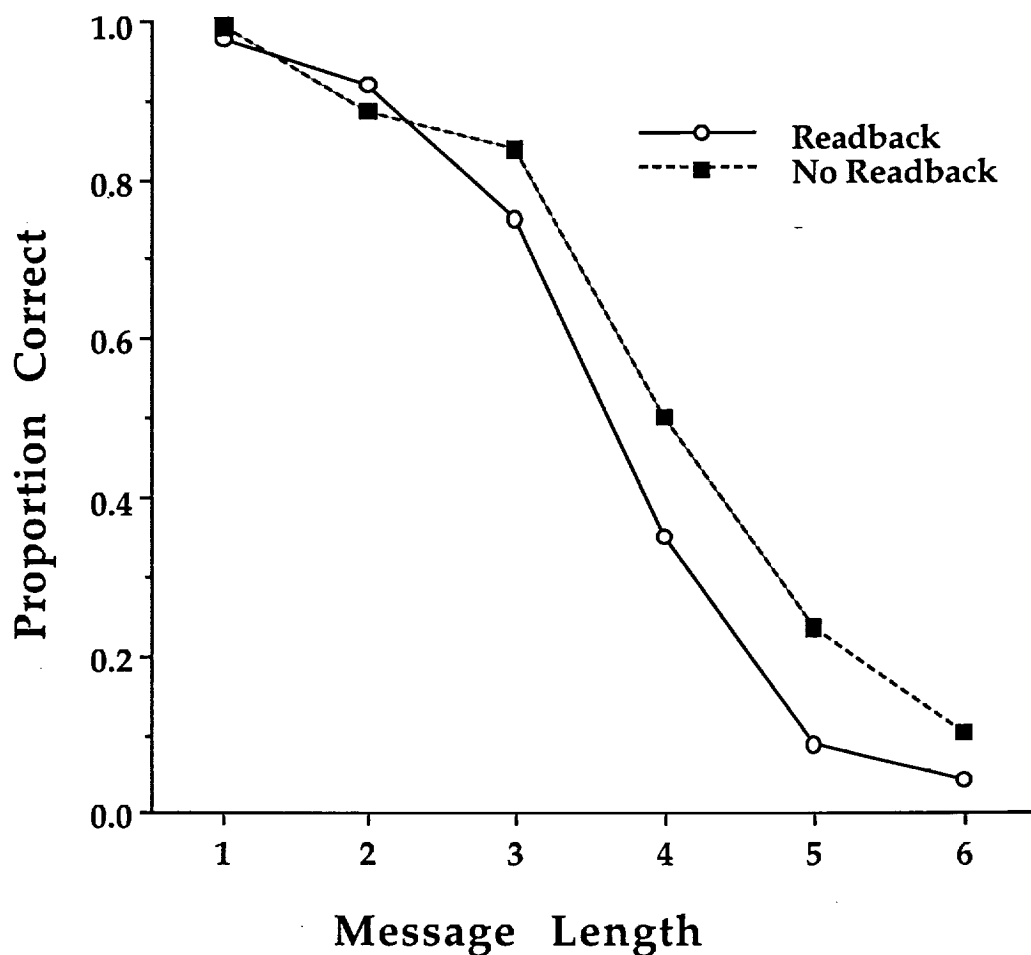
Further, the effect of readback on accuracy depended on the combination of wordiness and message length. Readback had the largest disadvantage for redundant messages of Lengths 3 to 6.
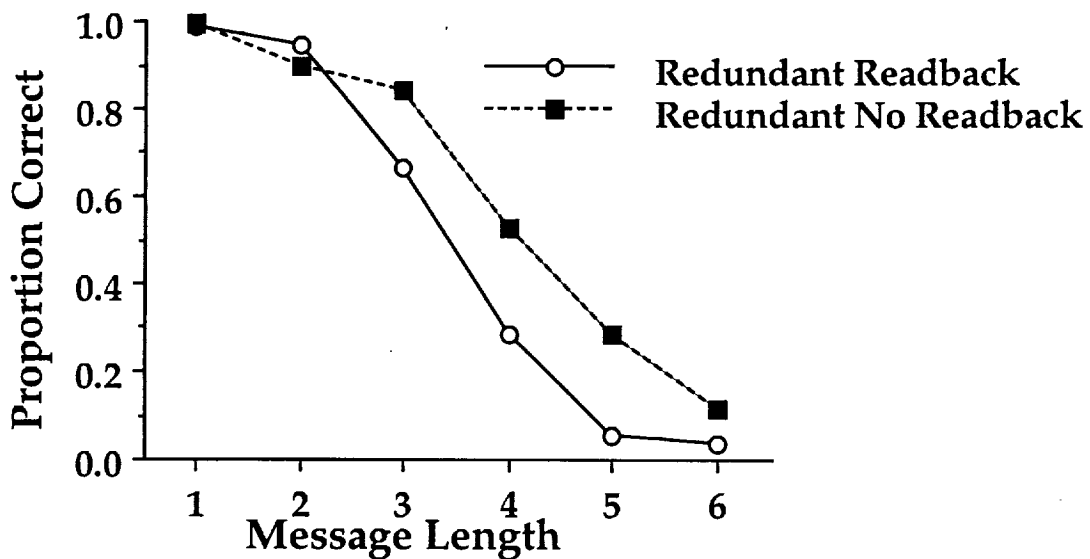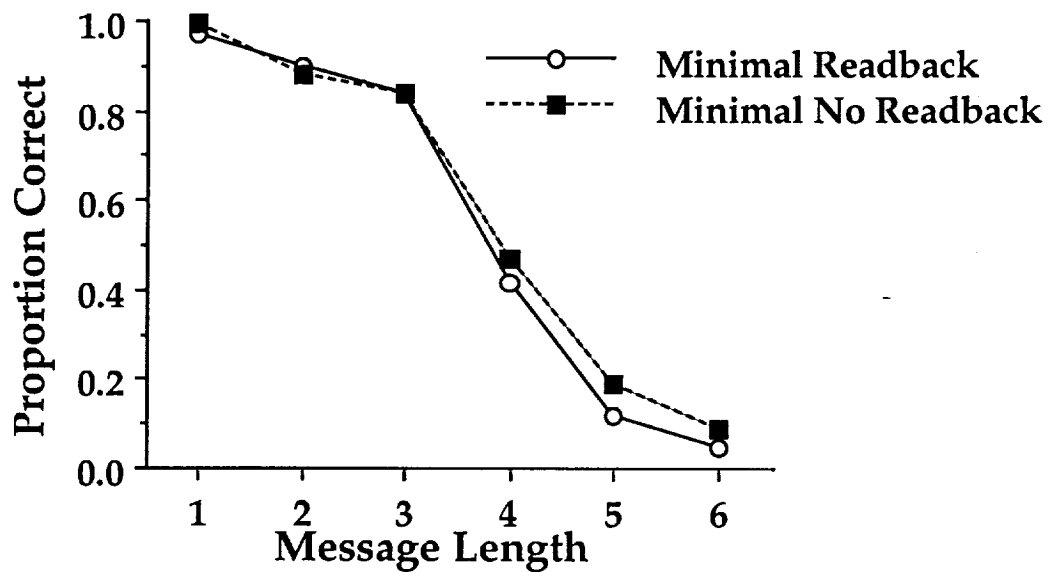
Moreover, the effect of readback on accuracy depended on the combination of modality and message length. There was a disadvantage for readback at all message lengths with the visual modality but only at message Lengths 4 to 6 with the auditory modality.
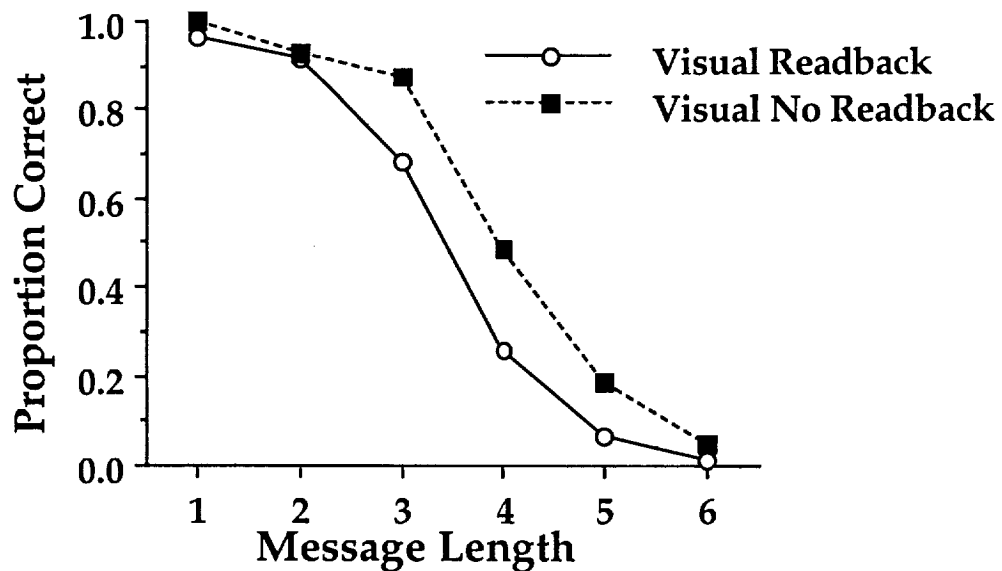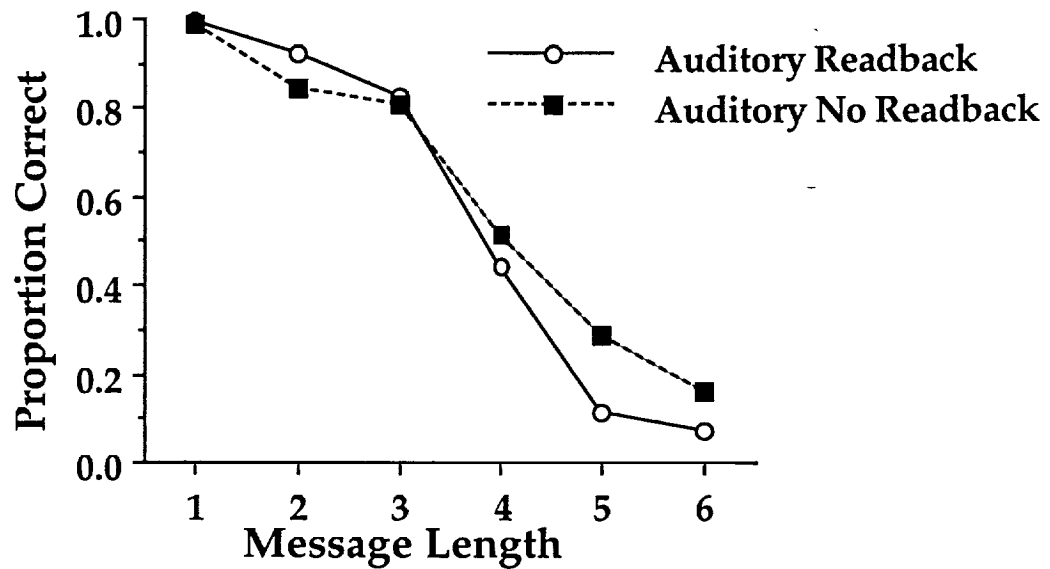
SUMMARY

Readback depressed performance especially

(1) with redundant messages
required more verbal output
than minimal messages

(2) with messages of Lengths 3 to 6
required more verbal output
than messages of Lengths 1 and 2

(3) with the visual modality
phonological recoding
necessary

CONCLUSIONS

We found little overall difference between the two modalities, but subjects had difficulty processing the longer and the wordier messages in the time allotted when they were presented in the visual modality. This result may be due in part to the fact that all the words were presented simultaneously in the visual modality, so that subjects might not have budgeted their time sufficiently well and spent too much time on the earlier words, missing the later words.

Readback generally depressed performance, especially with redundant messages, with longer messages, and with the visual modality. We attribute the negative impact of readback to the harmful effects of verbal output interference because the disruption was greatest when verbal output was largest.

We found that performance declined sharply with increases in message length and that readback was especially harmful with longer messages. Hence, when readback is required, as it is in the aviation situation, controllers and others giving instructions are advised to limit the number of commands in their messages.

AUTHOR NOTES

REFERENCES

Barshi, I. (1997). Effects of linguistic properties and message length on misunderstandings in aviation communication. Unpublished doctoral dissertation, Department of Linguistics, University of Colorado, Boulder.

Barshi, I. (1998). The effects of mental representation on performance in a navigation task. Unpublished doctoral dissertation, Department of Psychology, University of Colorado, Boulder.

Barshi, I., & Healy, A. F. (1998). Misunderstandings in voice communication: Effects of fluency in a second language. In A. F. Healy & L. E. Bourne, Jr. (Eds.), Foreign language learning: Psycholinguistic studies on training and retention (pp. 161-192). Mahwah, NJ: Erlbaum.