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The Role of Temporal Overlap of Visual and Auditory Material in Forming Dual Media Associations

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Technical Report No. 113-ONR

Institute of Cognitive Science
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Boulder, Colorado 80309

April, 1982

This research was sponsored by the Personnel and Training Research Programs, Psychological Science Division, Office of Naval Research, under contract No. N00014-78-C-0433, Contract Authority Identification Number NR 157-422

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER 113-ONR	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) The Role of Temporal Overlap of Visual and Auditory Material in Dual Media Comprehension		5. TYPE OF REPORT & PERIOD COVERED Technical Report 6. PERFORMING ORG. REPORT NUMBER ONR
7. AUTHOR(s) Baggett, Patricia		8. CONTRACT OR GRANT NUMBER(s) N00014-78-C-0433
9. PERFORMING ORGANIZATION NAME AND ADDRESS Institute of Cognitive Science University of Colorado-Campus Box 345 Boulder, CO 80309		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS NR 157-422
11. CONTROLLING OFFICE NAME AND ADDRESS Personnel & Training Research Programs Office of Naval Research, Code 458 Arlington, VA 22217		12. REPORT DATE March, 1982 13. NUMBER OF PAGES 38
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This paper contains some results about forming associations between the visuals and spoken material in a dual media presentation such as film or television. In particular, it reports the role played by the overlap in time of visual and auditory linguistic material. Fourteen groups of college students were shown a 30 min film which introduces an assembly kit, its pieces, their names, and some of their uses. The film's visuals and narration could be presented in synchrony or one could be shifted relative to the other up to 21 sec. Subjects saw the film in one of seven versions: visuals moved relative to narration by -21,

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-14, -7, 0 (synchrony), 7, 14, or 21 sec. They were tested immediately or after a week for recall of the names, given the pieces. Scores were highest at zero- and 7-day delay for two groups: synchrony, and visuals 7 sec before narration. At 0-delay, each of the other five groups scored about 80% of the highest groups. At 7-day delay, the other five groups scored differently: the 3 narration first groups were about 30% less than the two visuals first groups. The temporal order in which visual and auditory elements are presented differentially influences the formation of dual media associations. When auditory precedes visuals, much of the auditory component is lost. Two possible theoretical interpretations are given, and practical applications are discussed.

The Role of Temporal Overlap of Visual and Auditory Material in Forming Dual Media Associations

Abstract

This paper contains some results about forming associations between the visual and spoken material in a dual media presentation such as film or television. In particular, it reports the role played by the overlap in time of visual and auditory linguistic material. Fourteen groups of college students were shown a 30 min film which introduces an assembly kit, its pieces, their names, and some of their uses. The film's visuals and narration could be presented in synchrony, or one could be shifted relative to the other up to 21 sec. Subjects saw the film in one of seven versions: visuals moved relative to narration by -21, -14, -7, 0 (synchrony), 7, 14, or 21 sec. They were tested immediately or after a week for recall of the names, given the pieces. Scores were highest at zero- and 7-day delay for two groups: synchrony, and visuals 7 sec before narration. At 0-delay, each of the other five groups scored about 80% of the highest groups. At 7-day delay, the other five groups scored differently: the 3 narration first groups were about 30% less than the two visuals first groups. The temporal order in which visual and auditory elements are presented differentially influences the formation of dual media associations. When auditory precedes visuals, much of the auditory component is lost. Two possible theoretical interpretations are given, and practical applications are discussed.

The Role of Temporal Overlap of Visual and Auditory Material in Forming Dual Media Associations

In many dual media presentations such as film and television, human speech is used in the sound track to label or describe or explain or comment in some way on the visual images. When the speaker is not seen in the visual images, such narration is called voice over (Jacobs, 1970; Monaco, 1977). Educational and instructional films, documentaries, and television commercials frequently have sound tracks whose speech consists, partly or entirely, of voice over narration. It is simpler to prepare than lip-sync narration (synchronization between the movement of the mouth of a person in the visual image and the words on the sound track), and it can be created after the visual images are filmed, allowing for flexibility in verbal content.

This paper reports results concerning the role of the overlap in time of the visual and voice over narration material in forming dual media associations. (Henceforth, the term narration will be used to mean voice over narration, and the term visuals will be used to mean the visual images of a film or videotape.) In this study, the narration and the visuals to which the narration corresponds are shifted in time. For some presentations, the visuals come early; for others, the visuals and corresponding narration come simultaneously; and for others, the narration comes early.

We are testing one aspect of comprehension, the creation of associations between visuals and narration, and in particular, the association of an object with its name. We assess whether associations have been formed by testing in one direction only. The cue is visual (an object), and recall of the verbal part (the object's name) is measured.

The experiment presented here does not show how people in the various groups with visuals and narration shifted in time would perform on some other tasks. For example, it does not test how well they would answer questions based on the film or give summaries of it, or perform tasks shown in the film. Our focus is to establish the role of temporal overlap in forming dual media associations.

Depending on the experimental outcome, any of several different hypotheses about dual media processing may be supported or rejected. We will briefly discuss four different hypotheses and the predictions they make.

A. First is the dual code hypothesis, whose most well known proponent is Paivio (1971). It assumes that visual material and verbal material are stored in two separate memories. Internal associations between the two are formed by some internal processing which does not have to occur at the time of encoding. This hypothesis is attractive. It says that people can be presented visual and verbal material at different times and still make very good associations. The prediction from the dual code hypothesis is that a relatively small shift of visual and verbal materials should not have any influence on the ability to form associations. This prediction is graphed in Figure 1a.

Insert Figure 1 about here

B. The second hypothesis is similar to A, in that it assumes that there are two memories in which information is stored, one for visual and the other for verbal. It differs from A in that it assumes that associations between the two are formed at the time of encoding, when the information is stored, that is, within some relatively small period of time.

Hypothesis B has two versions. Hypothesis B1 assumes that visual and verbal items are put into memory at the time that they are physically presented. It therefore predicts that the best associations are formed with a synchronous presentation, and that there is a uniform drop in both directions, when visual precedes verbal and vice versa.

Hypothesis B2 assumes that synchrony in putting visual and verbal items in memory is not necessarily equivalent to the physical presentation of the stimulus. In particular, it assumes that the text consists of linguistic units, processed in cycles (as in the theory of Kintsch and vanDijk, 1978). Each linguistic unit has to be divided into propositions, which are linked together into a coherence graph. Only then can the conceptual unit be stored. The verbal information cannot be ready for storage, for example, until a phrase is finished, and the text base has been formed. Associations from verbal and visual are best, then, when the actual text precedes the visuals. This causes the text base to be synchronized with the visuals.

Thus, there are two predictions from hypothesis B: either (1) the best associations are made with visuals and narration in synchrony; or (2) there will be some advantage when the narration precedes the visuals. These predictions are shown in Figure 1b.

C. The third hypothesis assumes a single conceptual memory that operates as a semantic network. (Many researchers including Anderson (1976), Collins and Quillian (1969), Kintsch & vanDijk (1978), and Norman & Rumelhart (1975) make this assumption.) Nodes in the network correspond to concepts. It is important to note that the formulation here differs from those of the authors cited above, in that concepts do not correspond to linguistic units. Concepts can consist of elements arising from different media, for example, linguistic and pictorial. When an instance of the concept is created, it will be connected to the already existing semantic network. (Connections and associations have the same meaning here.)

An individual concept has some number of associations. For example, if the word "red" is spoken, it can connect to, or associate with, the visual concept of an object that is red.

Examples of the connections (associations) made can be seen when subjects are naming some object. In a previous study (Baggett and Ehrenfeucht, in press) we asked people to name pieces in an assembly kit. The kit is the same one used in this experiment. Figure 2 shows a piece from the kit and Table 1 shows the words generated, separated into modifiers and nouns. These words are associated to the object shown in Figure 2.

Insert Figure 2 and Table 1 about here

The main assumption of this hypothesis is that visual concepts are able to form more associations than verbal concepts, which are far more limited. We refer to this difference as "bushy" and "skimpy" concepts (Baggett, note 1). For example, it is possible that a concept formed from a physical object can be associated with the verbal expressions "red block", "orange brick", etc., as well as to other concepts formed from physical objects. On the other hand, we assume that a concept formed from the verbal expression "red block" has fewer associative possibilities. It is important to remember that concepts are not necessarily linguistic.

Consider the situation when one wants a direct association between two concepts. One concept is more bushy (can form more associations) than the other. The proper order in which to present the two concepts is to give the more bushy one first, and the less bushy one later. The mathematical formulation will not be given here, but the idea can be illustrated with a simple example (see Figure 3). Assume the already

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Insert Figure 3 about here

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existing network E will permit four connections to be made, of types 1, 2, 3, and 4. Two concepts are coming in as input to E. Concept X is able to form connections of types 1, 2, 4, and 5. Concept Y is able to form only those of types 3 and 5.

Concept X is thus more bushy than concept Y. We assume that X and Y will connect to E. We want them to connect to each other as well. X and Y can be connected only by joining 5 with 5. What is the chance of this connection, depending on which (X or Y) comes first?

We assume that if connections are possible, they are done with the same probability, and only one connection is needed. Suppose X (more bushy) comes first. This situation is shown in Figure 3(I). By assumption, it connects with the existing network, by any one of 1, 2, and 4. Next comes Y (less bushy). By assumption, it must also connect to the existing network, which now includes X. It will connect by either 3 or 5, each with a 50% probability. It can connect to X only by 5, and to E excluding X only by 3. Therefore, the probability that Y will connect to X is 50%. This is the outcome when the more bushy concept is presented first. It is illustrated on the upper right of Figure 3.

Now suppose Y, the less bushy concept, comes to the existing network first. This situation is shown in Figure 3 (II). Y connects by 3. Next comes X, with four possibilities (1, 2, 4, and 5) of connecting with E. Only one of these (5) is a connection with Y. Therefore, X's chance to connect to Y is 25%. This is shown on the lower right of Figure 3.

This example illustrates that the chances of creating a compound concept whose parts are presented in two modalities depends strongly on the order in which the parts are presented. Hypothesis C1 predicts that verbal material (skimpy concepts) following visual (bushy concepts) is best. Hypothesis C2 makes a slightly different prediction: Possibly, processing linguistic material is slightly delayed relative to visual (as in the argument in B2 above), so that either delaying verbal material slightly, or presenting it in synchrony with visual, leads to the best connections. These two predictions are graphed in Figure 1(c).

D. The fourth and final hypothetical framework gives the same predictions as the previous one, but is based on a different model.[1] Paivio (1971) can be given credit for this one, as well as Kosslyn (1980). Linguistic material, according to this framework, automatically creates visual images. The visual images created are based on previous visual inputs. When verbal material follows visual, the verbal material becomes associated with the just previously presented visual image. When verbal material precedes visual, the visual images that it associates with (call them V) are not necessarily related to the coming visual image (call it V1). The visual images automatically associated (V) make the correct association to V1 difficult. This framework predicts, as did C, that visuals and narration in synchrony, or narration following visuals, will cause the best associations to be formed.

Four different hypotheses, and the predictions they make about dual media processing, have been discussed. Summarizing, they are:

A. Dual code memory, with associations made at any time. Prediction: performance will not vary with the temporal shift.

B. Dual code memory, with associations made at the time of processing. Prediction: performance will be best when visuals and narration are in synchrony, or when narration precedes visuals.

C. Bushy and skimpy concepts. Prediction: performance will be best when visuals and narration are in synchrony, or when visuals precede narration.

D. Mental imagery. Prediction: same as (C).

Method

Subjects. Three hundred thirty-six students in Introductory Psychology at the University of Colorado participated as part of a course requirement. They were randomly assigned, in groups of one to five, to one of 14 experimental conditions, with 24 subjects per condition. Half of the conditions consisted of film presentations at one of seven temporal overlaps, with subjects tested immediately afterwards. The other half consisted of the same temporal overlaps, with subjects tested one week later.

Design. The experiment was a 7 x 2 between subjects design. There were seven types of temporal overlap (visuals 21, 14, and 7 sec before narration; visuals and narration in synchrony; visuals 7, 14, and 21 sec after narration), and two delays (0- and 7-day).

Stimulus Materials. The film, a 30 min color presentation, was shot, edited, and narrated by a professional film maker, James Otis, using silent super 8 film. It featured an assembly kit, Fischer Technik 50, which is similar to Lego. The kit, manufactured in Germany, has 120 total and 48 different plastic, metal, and rubber pieces. The smallest piece is $5mm^2$ ($.2\ in^2$) and the largest, shown in Figure 2, is 90 x 45 mm (3.54 in x 1.77 in). The manufacturers recommend its use by children as young as six through adults.

Names to be used in the narration for the 48 different pieces were selected using a method described in Baggett and Ehrenfeucht (in press). The names are simple, short, easily matched with their physical referents, and fairly well recalled. They also form categories. In general, a name for a piece consisted of a noun (the category name) and an adjective modifier, to differentiate the piece from other members of the category.

The film presents the 48 pieces in six different scenes, corresponding to six categories of pieces. These are: 4 blocks, 9 joints and rails, 6 platforms and plates, 8 rods, 10 wheels, gears, and other round pieces, and 11 special pieces. The names are given in Appendix 1. The film has 1626 words of narration. The narration describes the pieces, gives their names and names of their features, and describes some of their uses. The first words of narration are given in Appendix 2.

Using a specially constructed electronic arrangement, simply by setting a timer, we could shift the narration and visuals with respect to one another. We selected seven such shifts: visuals 21, 14, and 7 sec before narration; visuals and narration in synchrony; and visuals 7, 14, and 21 sec after narration.

The narration and visuals were the same for all 14 conditions. All that varied was the overlap in time of corresponding elements. Expressions such as "This is..." or "What you see here..." were avoided in the narration.

In the extreme conditions (visuals 21 sec before or after the appropriate narration) the viewer could occasionally be hearing about piece X while seeing piece Y.

Procedure. Subjects were run in small groups. The instructions were: "Today you are going to see a film which introduces you to an assembly kit of pieces, their names, and some of their uses. The kit is similar to Lego. After the film, which lasts about 1/2 hour, you will be given a task to do, based on what you have seen and heard. So just pay attention to the film." (The people in the 7-day delay groups were told to come back one week later to do the task.) Subjects were not told the exact nature of the task.

After the film, and at the appropriate delay, each subject was given a collection of the 48 actual pieces from the kit, a sheet with 48 numbered blanks, and a folder with 48 colored photos of the pieces. The photos were numbered 1 to 48, to correspond to the blanks. The subject was instructed to write in blank one, the name of the piece shown in photo one, etc. If the subject had any doubt as to which of the 48 pieces was pictured in a photo, he or she was instructed to ask the experimenter, who would show him or her the actual piece. The subject was further instructed to write the names exactly as they had been given in the film.

Subjects were told there was no penalty for guessing. They finished the task in 15 to 30 min. Before leaving, they filled out a questionnaire indicating whether they had played with the kit before.

Results and Discussion

The data are from 336 subjects. None of them was familiar with the Fischer Technik assembly kit, according to answers on their questionnaires. The dependent measure was percentage correct on recall of the names, using the pieces as cues. A strict scoring criterion was used: Any deviation from exactly correct was scored as wrong.

Table 2 presents percentages correct and standard errors (in parentheses) for each of 14 groups. Figure 4 shows the results graphically. Results of statistical tests are given in Table 3.

Insert Tables 2 and 3 and Figure 4 about here

Two groups scored equally high at zero delay: in synchrony (S) and visuals 7 sec before narration (V+7). Their means are 45.57 and 44.09% respectively. Also, two groups scored equally high after a 7 day delay: In synchrony (S) and visuals 7 sec before narration. Their means are 30.12 and 29.94%. (See test 4 in Table 3.)

At zero delay, the five other groups scored significantly lower than S and V+7. (Test 5 in Table 3.) But scores in the five groups were not statistically different from one another. (Tests 2 and 6 in Table 3.) Thus, at zero delay, subjects recall the pieces' names best in S and V+7. In all other groups they are able to recall some names, about 80% as well (35.94/44.85) as in S and V+7.

The story is different after a week. As at zero delay, in synchrony (S) and visuals 7 sec before narration are best. The other five groups are significantly lower. However, the five groups are not identical, as they were at zero delay. The three narration first groups (narration 21, 14, and 7 sec before visuals) average only 19.8% correct. The two visuals first groups (visuals 21 and 14 sec before narration) average 25.4%, over 28% higher. The three narration first groups score significantly lower than two visuals first groups. (Test 3 in Table 3.)

We operationally define a measure of retention to be the ratio of the percentage correct after a week to the percentage correct at zero delay. The average retention for the three narration first conditions is 55.4%. For visuals 21 and 14 sec before narration, retention is 70.9%. For the conditions, in synchrony and visuals 7 sec before narration, retention is 66.9%. For good retention, it is better to err in the direction of early visuals than of early narration.

The main finding is an asymmetry in the temporal shift, as shown in Figure 4. When visuals precede narration by up to 7 sec, recall is as good as when visuals and narration are in synchrony. When narration precedes visuals by 7 sec or more, much of the narration is lost, especially after a delay.

The experimental results reject hypotheses A and B in the Introduction about the mechanisms involved in forming dual media associations. They support hypotheses C (bushy and skimpy concepts) and D (mental imagery), and do not distinguish between them.

Applications

If either hypothesis C or hypothesis D is not rejected by future experiments, the practical application to film makers of where to put narration is clear. Each hypothesis (C and D) makes the same claim, for a different reason: In a dual media presentation, the narration should follow, or be in synchrony with, the visual image, and never precede it.

Theoretically, the correct temporal overlap of visuals and narration is not restricted only to films with voice over narration. It should hold as well for illustrated lectures, slide shows, written text with pictures, etc. The principle is simple: One should present the visual part early, or simultaneous with the text. It is better to be too early with the visual part than too early with the text.

Reference Note

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Footnotes

Thanks go to James Otis for shooting, editing, and narrating the film used as stimulus material, to Jim Geidel and Ashley Godeaux for designing and implementing the electronic arrangement used when the film was projected, to Caroline Matsumoto for making the drawing for Figure 2, and to Steve Stewart and Kevin Carson for helping to run subjects. This work was supported by Office of Naval Research contract N00014-78-C-0433, and is 113 of the Institute of Cognitive Science's Technical Report Series.

[1] We thank Michel Denis for suggesting this formulation.

Table 1

Words generated by 14 subjects who named the piece shown in Figure 2. The number of subjects generating each word is in parentheses.

modifiers	nouns
large (10)	plate (6)
long (4)	platform (2)
base (6)	bar (1)
thick (1)	floor (1)
multipurpose (1)	fork (1)
perforated (1)	panel (1)
red (1)	waffle (1)
with holes (1)	zigzag (1)

Table 2

Mean Percentage Correct on Recall of the 48 Names of the Pieces, Given the Pieces as Cues, as a Function of Temporal Shift of Narration and Visuals, and Delay (zero or 7-day) Between Film and Test. (Standard error in parentheses)

	narration 21 sec before visuals	narration 14 sec before visuals	narration 7 sec before visuals	narration and visuals in synchrony	visuals 7 sec before narration	visuals 14 sec before narration	visuals 21 sec before narration
0 delay	38.10	32.20	37.76	45.57	44.09	35.85	35.68
	(3.79)	(3.62)	(3.27)	(3.69)	(3.98)	(3.26)	(3.25)
7 day delay	17.36	21.18	20.66	30.12	29.94	26.30	24.48
	(1.43)	(2.43)	(2.15)	(3.64)	(2.11)	(2.43)	(2.85)

Table 3

Statistical Analyses and Their Results

Analysis	Results
1. 7 x 2 between groups ANOVA (7 degrees of temporal shift x 2 delays)	Significant main effect of temporal shift, $F(6,322)=3.87$, $p<.05$ Significant main effect of delay, $F(1,322)=70.81$, $p<.001$ Non-significant interaction of temporal shift x delay, $F(6,322)<1$
2. At zero delay, the 3 narration first groups versus the groups with visuals 21 and 14 sec before narration	$t(118\ df)<1$
3. At 7-day delay, the 3 narration first groups versus the groups with visuals 21 and 14 sec before narration	$t(118\ df)=2.65$, $p<.01$
4. In synchrony versus visuals 7 sec before narration	$t(46\ df)<1$ (0 delay) $t(46\ df)<1$ (7-day delay)
5. In synchrony and visuals 7 sec before narration versus the five other groups	$t(166\ df)=2.96$, $p<.01$ (0 delay) $t(166\ df)=3.71$, $p<.01$ (7-day delay)
6. At zero delay, the five groups, excluding in synchrony and visuals 7 sec before narration	$F(4,115)<1$

Figure Captions

Figure 1: Predictions of performance in forming dual media associations made by four different theoretical frameworks. See the text for further explanation.

Figure 1a: Prediction of performance from dual code hypothesis, with associations formed at any time.

Figure 1b: Prediction of performance from dual code hypothesis, with associations formed at the time of encoding.

(1) items are encoded at the time they are physically presented.
(2) linguistic items have to be processed in cycles before the resulting conceptual unit is stored in memory.

Figure 1c: Prediction of performance from bushy versus skimpy concepts hypothesis, and from mental imagery hypothesis.

Figure 2: A piece from the Fischer Technik 50 assembly kit. Its actual size is 90 x 45 x 5 mm (3.54 x 1.77 x .2 in). Words that subjects generated in naming the piece are given in Table 1.

Figure 3: A direct association is wanted between concept X (bushy) and concept Y (skimpy). I shows the situation when X is presented to existing memory first. The probability that X and Y become associated is .5. II shows the situation when Y is presented to existing memory first. The probability that X and Y become associated is .25. Therefore, to increase the probability that X and Y are associated, the proper order is to present X first and Y later.

Table 3

Figure 4: The results in Table 2 presented in graph form. Mean percentage correct on recall, as a function of temporal shift of narration and visuals, and delay (zero or 7-day) between film and test.

Figure 1

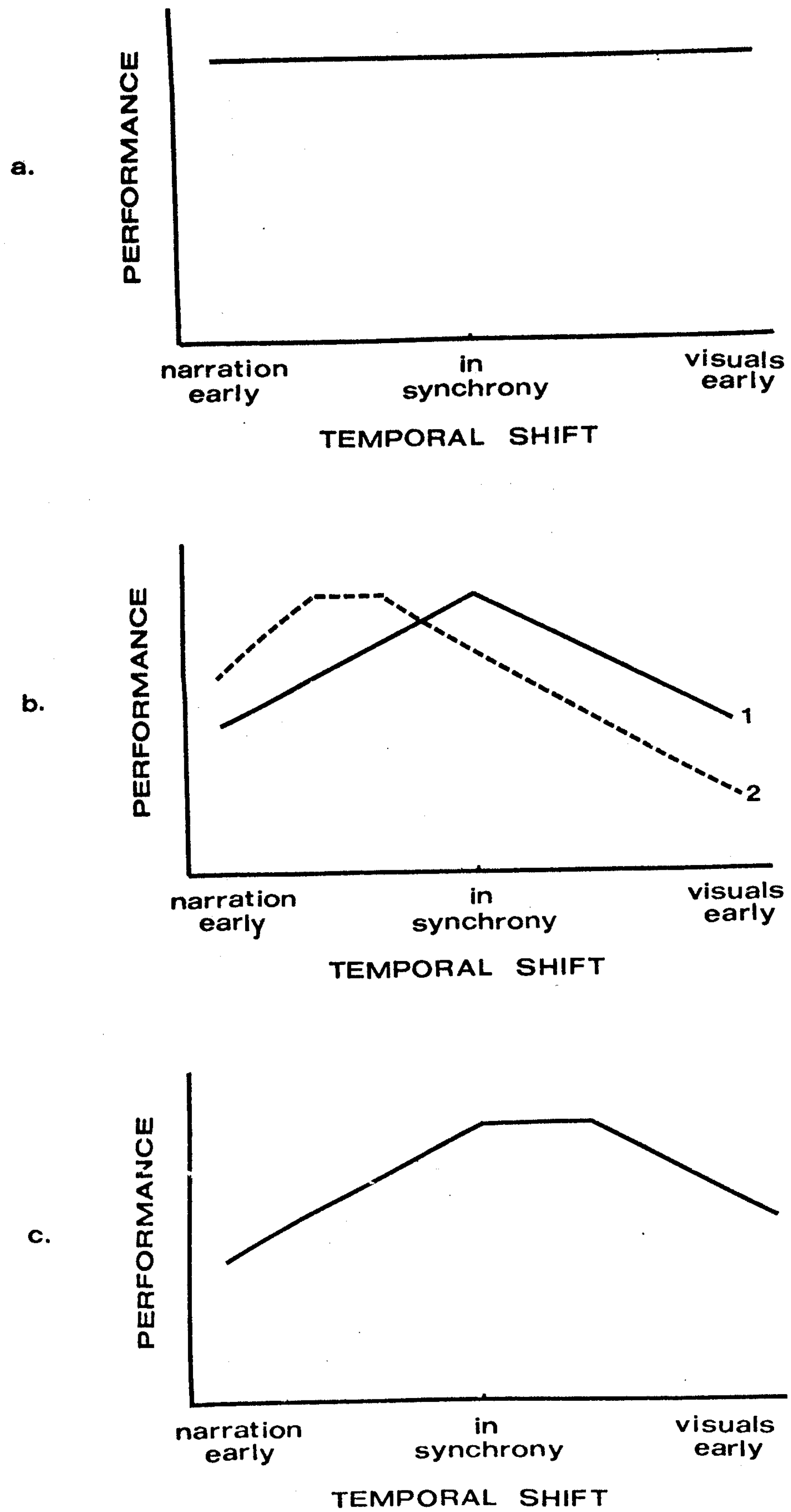
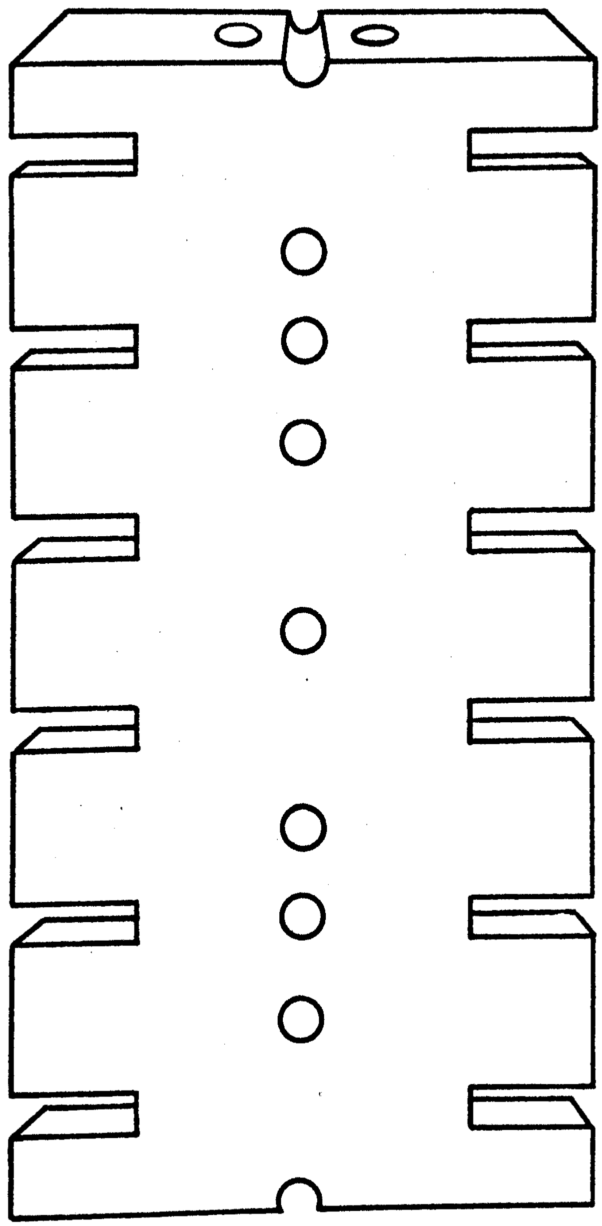

a.
PERFORMANCE
narration early
in synchrony
visuals early
TEMPORAL SHIFT
b.
PERFORMANCE
1
2
narration early
in synchrony
visuals early
TEMPORAL SHIFT
c.
PERFORMANCE
narration early
in synchrony
visuals early
TEMPORAL SHIFT

Figure 2



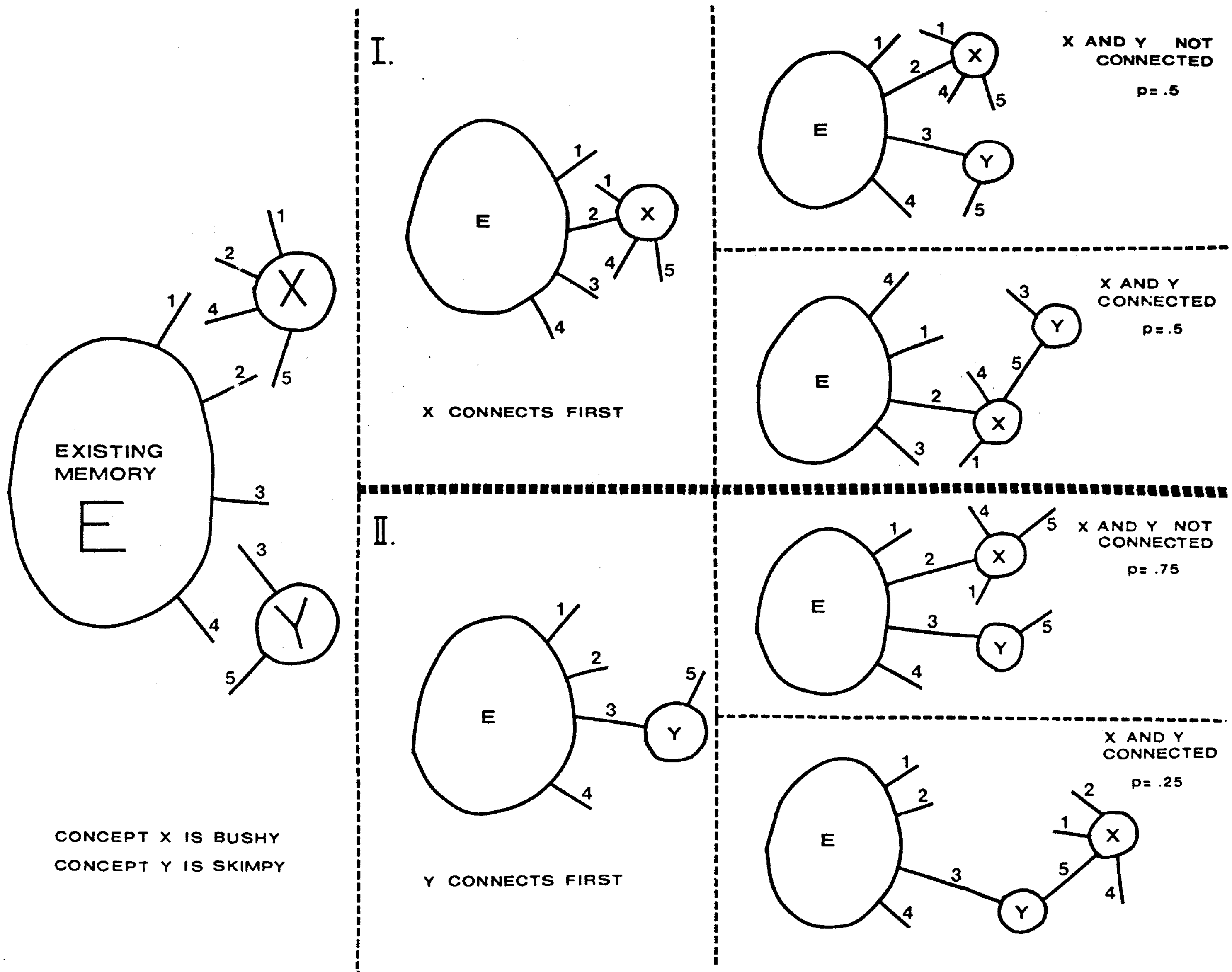

EXISTING MEMORY
E
X
Y
1
2
3
4
5
CONCEPT X IS BUSHY
CONCEPT Y IS SKIMPY
I.
X CONNECTS FIRST
II.
Y CONNECTS FIRST
X AND Y NOT CONNECTED
p= .5
X AND Y CONNECTED
p= .5
X AND Y NOT CONNECTED
p= .75
X AND Y CONNECTED
p= .25

Figure 3

Figure 4

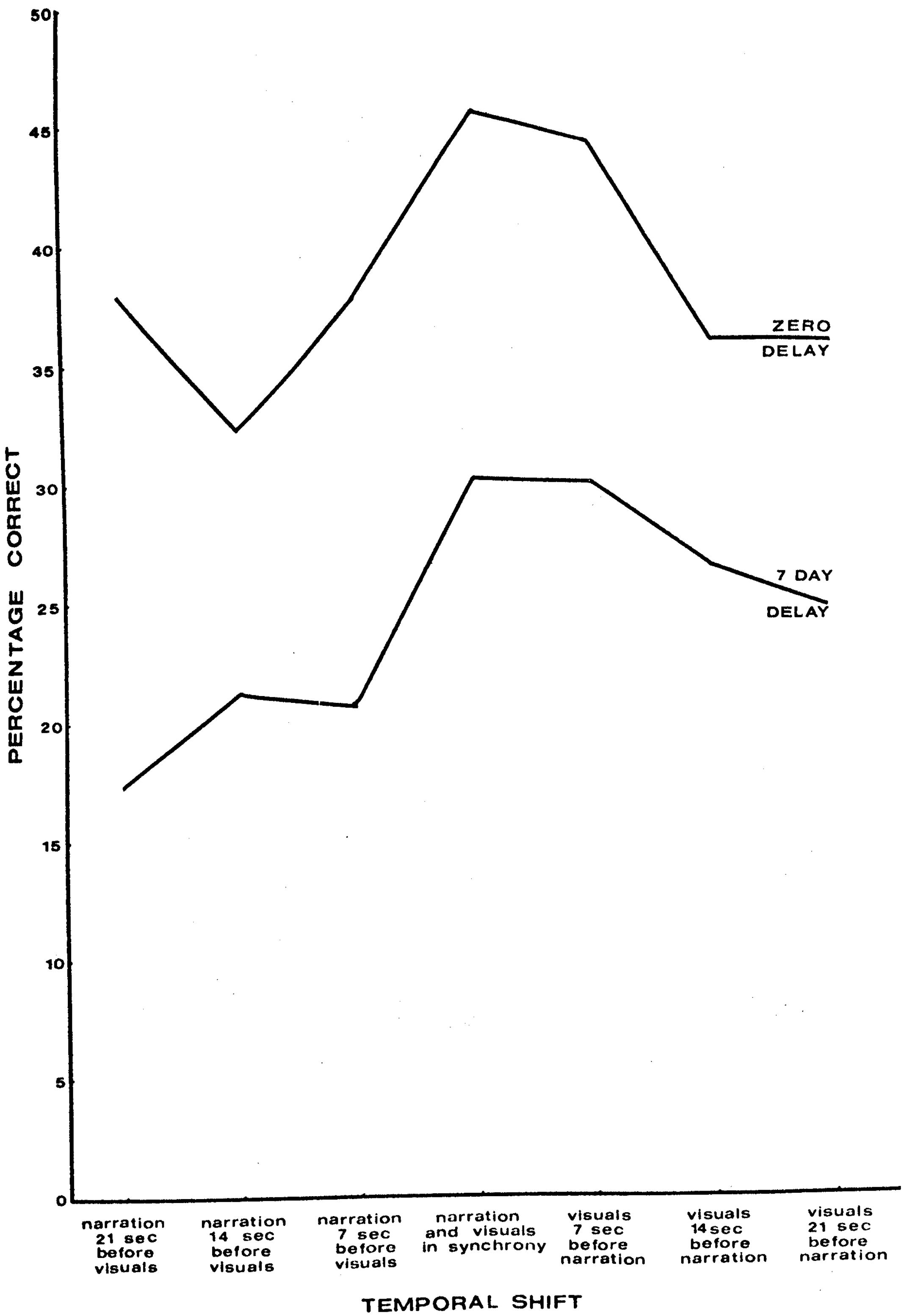


Figure 3

Appendix I

Names for the 48 pieces in the assembly kit, grouped according to the six scenes in the film

1. blocks

large block

large block with holes

small block

small block with red knob

2. joints and rails

cube joint

triangle joint

slanted joint

H-joint

flat square joint

corner joint

joint with half axle

long red rail

short red rail

3. platforms and plates

large platform (shown in Fig. 2)

small platform

narrow platform with half axles

large plate

medium plate

small plate

4. wheels, gears, and other round pieces

smooth red wheel

black ring

wheel with movable handle

tire

large black gear

small black gear

large red gear

small red gear

large pulley wheel

small pulley wheel

5. rods

short metal rod

medium metal rod

long metal rod

extra long metal rod

short grey rod

long grey rod

grey rod with square end

crankshaft

6. <u>special pieces</u>

string

crank

hook

spool

C-clip

red tube

spring

rubber band

1-hole hitch

2-hole hitch

3-hole hitch

Appendix 2

The opening narration to the film

This film is about an assembly kit that consists of 48 different plastic, metal, and rubber pieces. The largest piece is the large platform, and the smallest is the C-clip.

You can build many objects from the pieces. . . simple abstract structures. . . a unicorn. . . an antenna that moves when you turn the crank. . . a little car. . . a dump truck. . . that dumps!. . . or even a fanciful antennaed creature with plates. This film will introduce you to the different pieces, their names, and some of their uses.

The first category is blocks. There are four blocks. The first one is called the large block. It has a knob on one side and grooves on its other five sides.

An interesting object can be built using only four large blocks. The secret is to build two separate L-shapes, each with two large blocks, and then to join them. The large block.

The next one is the large block with holes. It is identical to the large block, except that there are two holes through its center.

The third block is the small block. Like all blocks, it is grey, with a knob on one side and grooves on its other five sides.

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