The Effects of Progressive Illustrations on Recognition of Paired-Associates

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Abstract: An interactive illustrative form known as progression was used in this study involving recognition of paired-associates items. Each stimulus-response pair was presented either side by side (non-interactively) or as a series of four panels, with the stimulus as the flrst panel. two Intermediate panels, and the response as the last panel. The Intermediate panels represented a gradual visual metamorphosis from the first item to the last. Subjects (244 undergraduates) saw elther non-Interactlve stimuli, or progressive stimuli with all four panels or only three panels. Testing occurred elther immediately or after two weeks. The non-interactive treatment group given the delayed test scored signlficantly lower than all other groups. A theory was proposed concerning progression as an interactive technique whlch provides a visual link that stimulates the viewer to create an associative semantic link. This process facilitates communication by engaging the vlewer In the message.

Résumé: Une illustration interactive et progressive fut utilisé dans cette étude sur la reconnaissance d'items pairés et associés, Chaque paire de stimulus réponse fut présenté soit côte à cote (non-interactif) ou dans une série de quatre panneaux: un premier panneau présentant le stimulus, deux panneaux intermediaires, et un dernier représentaient une métamorphore visuelle graduele du premier polnt au dernier. Des sujets (244 étudiants) ont pu remarquer un stimulus non-interactif, ou un sitmulus progressif avec soit quatre panneaux ou trots panneaux. L'analyse a été réaliseé soit immédiatement après l'experimentation ou deux semaines plus tard, tes résultats obtenus par le groupe ayant reçu le traitement non-interactif furent Inférieurs à ceux des autres groupes. Une théorie fut proposée concernant une progression tel qu'une technique interactive fournissont une liaison visuelle pour stimuler le spectacteur à créer une liaison sémantique associée. Ce processus facilite une communicatilon tout en attirant le spectateur vers le message.

Communication through images is afundamental teachingstrategy which has received a great deal of attention from researchers in educational technology. While specific picture variables have been studied (e.g., color, amount of detail, shading), much of the research todate has proceeded on the assumption that most pictures would function identically in a given setting. The theory proposed here adopte an alternative view, assuming that various types of pictures have different effects on the learner. The main impetus for this type

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of study is the creation of memorable images which will increase the probability that picture information will be retained over a long period of time. Of interest in this regard is interactive imagery.

Studies on interactive imagery and illustration have typically depicted the syntactic form ***subject-verb/preposition-object*** to associate two objects, thereby providing a direct correspondence between the illustration and the objects to be linked. The present theory proposes that learners can benefit equally well from complex interactive illustrations which associate concepts rather than objects. These may be defined as illustrations with two or more symbols, whose meanings do not directly reflect the intended message of the total image; the whole is more than the sum of the parts. Three major points summarize the theory. First, the learner interprets each of the symbols and then associates them in some way to derive the meaning of the message. Second, this indirect correspondence between the message and the given symbols forces the viewer to use past experiences and world knowledge to decipher the connection between the symbols, thereby increasing cognitive activity Third, this intensive cognitive analysis should strengthen the memory trace (Lockhart & Craik, 1990).

In essence, then, complex interactive illustrations engage the learner in a visual problem-solving dialogue by not immediately communicating the message. This encourages the learner to be an active participant in the learning process, rather than a passive receiver of information. Initially capturing the attention of the learner is a crucial step that interactive illustrations are capable of achieving.

In what instructional situations might this type of illustration be useful? Certainly their chief advantage is their ability to influence affective behavior, making them more appropriate for arousing emotion than for conveying factual information. For instance, they might be used to shape the learner's attitude in an introductory unit on drug abuse or illiteracy

A study dealing with one type of complex interactive illustrations is presented here. It points to another major attribute of these visuals, which is the potential for producing a long-term impact on memory Ultimately this is a goal which instructional designers and educators alike must look to in creating and choosing their materials for visual communication.

With regard to paired-associates learning, Bower (1972) speculated the facilitative recall effects seen when subjects engaged in mental interactive imagery were due to a strong associative link derived from the interactive image. Most of his subjects, he stated, linked their nouns in subject-verb-object or subject-preposition-object scenes. This allowed for both a semantic connection and an imaginal one, and Bower considered this mnemonic technique extremely helpful in paired-associates learning.

Levin (1981) pointed out that illustrations (external imagery) led to more consistent positive recall effects than mental images (internal imagery). He stated that, "visual perception and interpretation skills are required in internalizing an illustration, whereas cognitive constructions and elaborations are

required in creating imaginal representations of verbal messages" (p. 207). The former cognitive skills he considered to be less subject to individual differences and consequently more reliable for memory than the latter skills. He added that interactive images and illustrations were effective mnemonic strategies, and their use lessened the difference between recall results for mental images and illustrations.

A great deal of research has demonstrated the efficacy of interactive illustrations in paired-associates learning, and as in the mental imagery investigations, much of the interaction represents a syntactic relationship between a subject and an object. This could take the form of a spatial relation (e.g., The wagon is on the roof) or an active relation (e.g., The dog is chasing the bicycle). For instance, Lutz and Lutz (1977) usedstimulifrom the Yellow Pages to determine the effectiveness of interactivity with respect to brand-product pairs in advertising. While some of their interactive illustrations utilized letter accentuation (in which some characteristic of the product was depicted in the lettering of the brand name), the facilitative effects could be attributed mainly to the pictorial interaction items (a syntactic subject-object relationship, such as a messenger with a rocket on his back for ***Rocket Messenger Service).***

Another interesting study in interactive illustrations emphasized the idea of meaningful vs. non-meaningful interactions. Lippman and Shanahan (1973) used interactive visuals to teach new vocabulary words to elementary school children. In their first experiment they compared three types of letter accentuation with a line drawing condition and a word only condition. Accentuation significantly enhanced recall both immediately and one week after learning, mainly due to the accentuation condition with maximal figural unity; that is, the condition under which some characteristic of the referent was most completely incorporated into the written form of the new vocabulary word. The investigators pointed out, however, that accentuation was not a meaningful form of interaction, a point which led to their second experiment. Familiar noun pairs were presented in one of five forms: written word only; line drawing of response item plus stimulus word; accentuation of one word; verbal presentation of subject-verb/preposition-object sentence; and depiction of this sentence. The last two conditions were considered meaningful interaction conditions, and were found to be more facilitative for recall than accentuation, which in turn proved better than line drawings or written words. Lippman and Shanahan demonstrated that figural unity between the two members of the pair was sufficient to enhance recall, but that a semantic interaction in the form of a subject-verb/preposition-object sentence was even better.

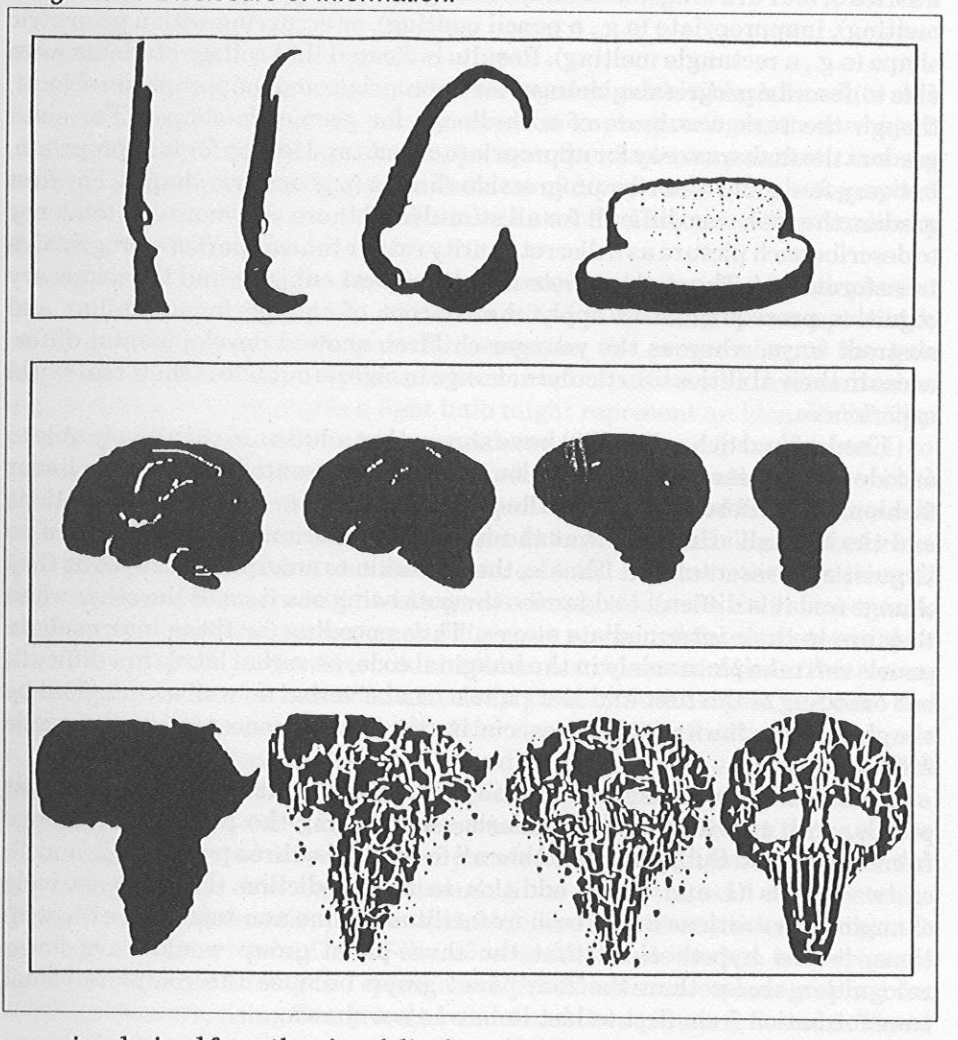
An alternative to a spatial or active interaction is one which might take place on a higher cognitive level requiring the formation of an idea or concept, One study by Abed (unpublished) made use of such an interactive technique in the form of visual puns. These are illustrations that associate two ideas or concepts to create a new meaning, often using a distinctive or witty reference as in a verbal pun. For instance, one visual pun contained the text ***Let my people*** go with the g in go formed by adjoining a hammer and sickle. Comprehension

of the visual pun required the association of textual and pictorial information in some new form that was not immediately available to the viewer. In other words, thinking about the visual was necessary for comprehension. Subjects (graduate students) saw either visual puns (interactive illustrations) or non-interactive visuals with equivalent messages. Intermixed with these during the presentation phase were other non-interactive distractor visuals: in Experiment 1 they were non-meaningful messages (pictures of common objects), and in Experiment 2 they were meaningful messages, such as a campaign poster depicting a candidate with a printed name across the top. Both immediate and delayed recognition tests revealed that interactive visual puns facilitated memory significantly more than non-interactive stimuli. However, the type of distractor intermixed with the puns had an effect on memory Long-term recognition memory remained high for visual puns when they were intermixed with non-meaningful distractors, but some decay over time was evident when meaningful distractors were used. This study demonstrated the feasibility of using interactive illustration stimuli for associating other things besides simple concrete nouns, specifically as a mnemonic strategy for concepts requiring higher cognitive levels for comprehension.

A common thread running through all these studies is the use of interactive stimuli in which the interaction occurs in a single illustration. An alternative might be a series of illustrations providing intermediate visuals linking the two pictured items to be associated. Dynamically changing an image of the first item into an image of the second can be achieved in a sequence of three or more visuals. This progressive disclosure of information provides a gradual visual link (or transformation) between the first and last visuals (see Figure 1 for an example on page 23). The two items to be associated are depicted in a series of simultaneously presented visuals which, viewed as a whole, provide the figural unity that Lippman and Shanahan (1973) stated was sufficient for an effective interactive illustration. Choosing two items that are related in some manner (though not necessarily in an obvious one, as in ***dog-***cut) can provide the meaningfulness that they considered necessary to strengthen the mnemonic role of interactive illustrations. This meaning could be conveyed in the syntactic sense through a subject-object relationship. Alternatively it could occur on a higher cognitive level as in the case of visual puns, so that a picture of ***Africa*** progressively changing to a picture of a skull might represent the fate of a continent, or the origin of the oldest human skull. The meaning derived from the picture pair is highly dependent on the individual, and text can be used for the purpose of communicating a specific message to the viewer.

The objective of the present study is to explore the technique of progression as a of interactive illustration. The abundance of research which demonstrates the efficacy of interactive imagery in facilitating memory suggest that showing subjects a progressive visual change between two items to be associated would result in better recognition than simply displaying the two items non-interactively (side by side). The present study is not designed to test the

Figure 1.
Progressive Disclosure of Information.



meaning derived from the visual displays, but merely to test their effectiveness for subsequent recognition.

An historical basis for this type of visual design was provided by the work of Schnall and his associates in the late 1960's and early 1970's. Their work involved the use of visual sequences which showed progressive change in color, position, or shape of the objects represented. Visuals were displayed one at a time rather than simultaneously. Generally the subjects' task required verbalization of the depicted events following presentation of the full sequence, and the results suggested a developmental trend in ability to integrate discrete pictures into a continuous serial change. Of particular interest here was a study by Kasdorf and Schnall (1970), in which the linguistic expression of

changes in shape (and other attributes) was measured. Change took place over a series of four drawings, with shape changes being appropriate (e.g., a candle melting), inappropriate (e.g., a pencil melting), or occurring with a geometric shape (e.g., a rectangle melting). Results indicated that college students were able to describe progressive changes for appropriate and inappropriate objects, though the task was more of a challenge for geometric shapes. For sixth graders the task was easy for appropriate objects and less so for inappropriate, but very few could describe progressive change in geometric shapes. For first graders the task was difficult for all stimuli and there was more of a tendency to describe each picture as a discrete entity rather than as part of a progressive transformation. The authors note that the oldest subjects had the necessary cognitive prerequisites to apply the concept of change in unfamiliar and abstract ways, whereas the younger children showed developmental differences in their abilities to articulate change in objects outside of their real world experiences.

Kasdorf and Schnall(1970) have shown that adults are cognitively able to encode and retrieve progressive visual changes presented to them in a linear fashion. The difference between the present series of progressive illustrations and the Schnall stimuli is that the intermediate stimuli used here have no linguistic representations. That is, they are akin to amorphous shapes as they change and it is difficult to describe them as being one item or the other when they are in their intermediate stages. Thus encoding for these intermediate panels can take place solely in the imaginal code, as verbal labels are difficult, but encoding of the first and last panels can be verbal as well as imaginal by simply labeling the items or by associating the two as a concept or in a syntactic form.

The stimuli were designed as easily recognizable items in the first and last panels, with two intermediate panels representing the progressive change from first to last. Subjects saw either all four panels, three panels (1,2, and 4), or two panels (1 and 4). In addition to the prediction that progressively changing illustrations would be more facilitative than non-interactive illustrations, it was hypothesized that the three-panel group would have lower recognition scores than the four-panel group because the complete visual transformation from first to last item was not shown.

METHODOLOGY

Subjects

Two hundred forty-four undergraduates were randomly assigned to one of six treatment groups. The three treatment conditions included two-panel visuals (non-interactive), and three-panel and four-panel visuals (both interactive). Half the subjects in each visual treatment condition were tested immediately after the learning phase and half were tested two weeks later, resulting in six treatment groups. Approximately 40 subjects were assigned to

each treatment group. Testing occurred in small groups of 8-11 subjects each (there were four test groups per treatment condition).

Materials

Thirty-two examples of progression were designed in black on white and in equal size. Four separate panels were drawn, beginning with one object which progressively changed its shape over the next two panels to become another object in the fourth panel. Each set of four panels was photographed as a whole with the four panels laid out in a horizontal sequence. The result was 32 black on white slides.

Each pair of items to be associated (pictured in the first and fourth panels) was represented by a phrase which described a meaning or concept which might be derived from the pair. For example, the progression of the gun changing to bread might represent the concept of military vs. humanitarian aid, or the brain changing to a light bulb might represent an idea. Reliability was established by presenting the paired-associates items (panels 1 and 4) to a class of approximately 15 graduate students. The students were provided with a list of the 32 descriptive phrases and they were asked to examine each pair and choose the appropriate descriptor. Interjudge reliability was between 88% and 92% for 25 pairs, and these were selected for use in the experiment. The purpose of this reliability testing was simply to ensure that some meaningful concept could represent each pair, since meaningfulness is essential in the utilization of progressive illustrations for communication. This same meaningful connection was not necessarily made by each subject, nor were the subjects asked what, if any, meaningful connection they made.

At the same time this class also judged the quality of the progression. The judges examined the 32 sets for two reasons. First, panels 1 and 4 needed to be easily recognized. Second, the progression designs werejudged in terms of how the changes occurred in each of the panels, with the judges looking for the presence of jump cuts (images changing too abruptly) and inconsistency (images changing direction, placement, etc). The 25 sets mentioned above met all these design criteria. One of the 25 was chosen at random to serve as a teaching example during the experiment. All 25 sets were photographed for slides twice more, using first panels 1 and 4 and then panels 1, 2, and 4. These two new sets were to serve as example and stimulus items for the two-panel and three-panel treatment groups. Again panels were photographed in a horizontal sequence.

The next phase involved establishing the reliability of the distractor items to be used during testing. Because the test was a four-item multiple-choice format, it was important that the three distractor items in the response not be related in any way to the stimulus items. Eight students were involved with this test. They were shown the stimulus panel and three distractors from each of the 24 stimulus sets, and were asked to identify any distractors which were either semantically or visually related to the stimulus panel. Distractor items were similar in size, placement, and lack of color to the stimulus sets, and were

Figure 2.
Sample Test Item with Stimulus Item on Left and Response or Distractor on Right. Correct Answer is "A".

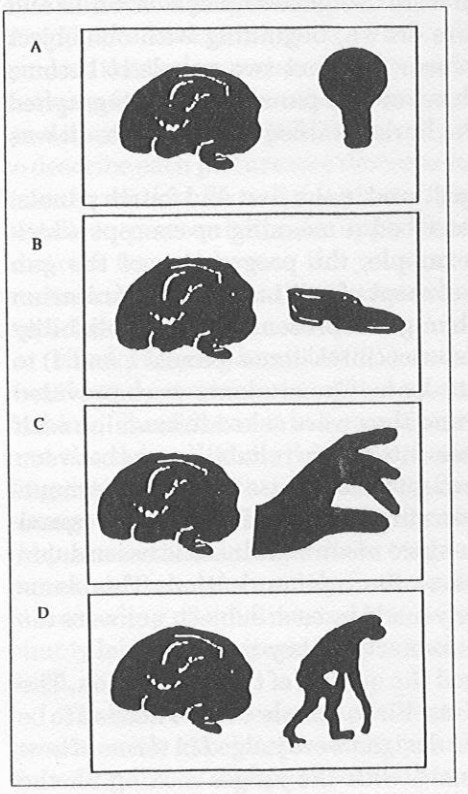
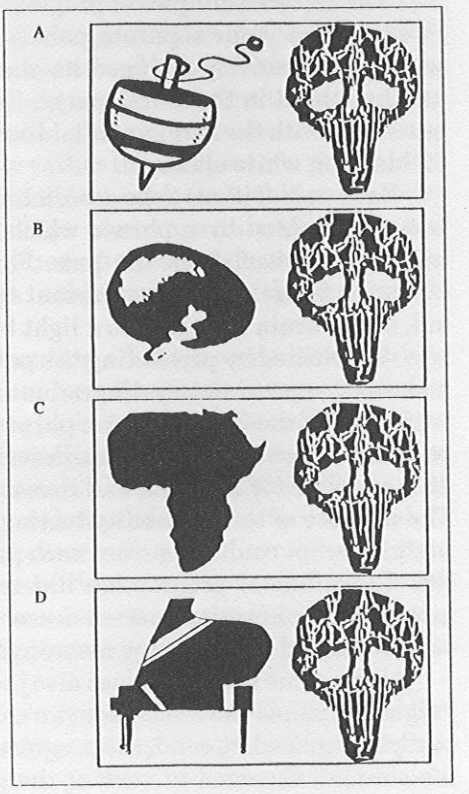


Figure 3.
Sample Test Item with Stimulus Item on Right and Response or Distractor on Left. Correct Answer is "C".



photographed for slides. Examples of distractors for two test items are shown in Figures 2 and 3.

Procedure

In the learning phase all treatment groups were first presented with the example slide. The technique of progression was explained to the experimental groups, and all groups were told that they would see more of the same types of slides. No indication was given of subsequent testing. Slides were shown for 4 seconds each using a Kodak slide projector and a constant screen size for all groups. Also, the same order of stimulus presentation was used for each group.

Testing procedures were identical for all groups. An example of the testing procedure was first given using the example stimulus from the learning phase. During testing stimulus-response pairs were projected onto the screen such that each stimulus item was seen consecutively four times: once with the correct response item and three times with distractors. These were presented

one after the other rather than simultaneously. Subjects were instructed to wait for a blank slide following all four pairs before recording their answer on a response sheet (so as to avoid cueing from other subjects and to force subjects to view all choices before deciding). Positioning of the correct response and the distractors in sequence was randomized across test items. Twelve of the stimulus test items were the first panel from the progression sets, while the other 12 were the fourth panel, and these were randomly intermixed. Also a different random order of presentation was used from the one in the learning phase.

RESULTS

The dunn-Bonferroni t statistic was used to test nine planned comparisons. Of interest were the 3-panel vs. the 2-panel scores at each test interval; the 4-panel vs. the 2-panel scores at each teat interval; the 3-panel vs. the 4-panel scores at each test interval; and the immediatevs. the delayed scores for the 2-, 3- and 4-panel conditions. With a significance level of .01 and 238 degrees of freedom, the critical value was 3.17. This was exceeded for three comparisons. Both the 3- and 4-panel delayed scores were significantly higher than the 2-panel delayed score, and the 2-panel immediate score was significantly higher than the 2-panel delayed score.

TABLE 1
Means and Standard Deviations for Recognition Test

	Immediate			Delayed		
	X	SD	N	X	SD	N
2 Panel	22.0	2.7	41	17.7	3.6	39
3 Panel	23.0	1.2	39	21.6	3.6	42
4 Panel	23.4	1.0	43	23.1	1.3	40

DISCUSSION

No difference was detected between the interactive and non-interactive picture conditions in the immediate testing situation. The fact that mnemonic strategies did not facilitate recognition could have been due to spontaneous mental imaging on the part of the subjects in the non-interactive group. Alternatively, and more lieu, a ceiling effect may have occurred. It has been well established that recognition memory is excellent in humans (Levie

Hathaway, 1988), and far more test stimuli may have been necessary to perceive any difference between groups in an immediate test situation. A similar result appeared in a study by Jusczyk, Kemler, and Bubis (1975), who tested adults' and children's memory ofverbally presented subject-verb-object sentences. Treatment conditions included verbal presentation only, verbal presentation plus picture, and verbal presentation plus mental imagery instructions. For the adult group no differences in immediate recognition memory could be found, although differences among the various conditions were apparent for free recall.

Given the favorable results of past research on interactive illustrations, it was not surprising that the interactive progression illustrations were facilitative in the delayed recognition of associated pairs of pictures relative to the non-interactive side-by-side displays. What elements rendered the former illustrations more memorable than their counterparts? Two major components make up these progressive illustrations. First, the visual element of the illustrations was unique in its dynamic characteristic. Kasdorf and Schnall (1970) showed that adult subjects were capable of applying the concept of change to abstract events. The changes taking place in the current progressive stimuli were clearly abstract, and the positive results obtained with them suggest that these subjects were also able to visually interpret the progressive changes through the four panels of the illustration. This leads to the second, or semantic, component. What sort of interpretation was applied to the progression stimuli?

One of two types of meaning might be applied to either the progressive or the non-interactive stimuli (assuming that subjects applied any meaningful association at all). The typical spatial or active relationship attributi to noun pairs was unlikely to occur in at least some of the pairs used for this experiment. Certainly a pair such as a communist symbol and a question mark would lend themselves more to the complex idea of the future of communism than to some spatial or active relationship (see Figure 4 for illustration). While it is difficult to ascertain how often these higher levels of cognitive activity are employed without directly questioning the subjects themselves, it is probable

Figure 4.
Example of Four Panel Progression.

that this type of activity occurred at least some of the time. It has been shown that adults spontaneously engage in mental interactive imaging for non-interactive stimulus pairs (Bower, 1972; Paivio, Yuille, & Smythe, 1966). It is possible that the visual link occurring through progression sparks some associative activity on a conceptual level. This hypothesis is explored more fully further on in the discussion, and might be the basis for future research on progressive illustrations.

Referring back to past research, the data from the experiment on visual puns demonstrated that adults were able to benefit from interaction as a mnemonic device even when more difficult cognitive processing was required. ndeed, it is difficult to imagine that all advertisements rely on the simple syntactic formats used in the interactive illustration studies on brand/product pairs in advertising (e.g., Lutz & Lutz, 1977). Surely any number of advertisements can be found that require consumers to associate cognitively complex ideas.

The role of the visual and semantic components of these progressive and non-interactive illustrations might be put into theoretical perspective by considering the dual coding theory. The non-interactive pictures, displayed side by side, required imaginal encoding, and had the potential for verbal encoding as well. Although the illustrations were not accompanied by text, Paivio (1971) has suggested that adults spontaneously attach verbal labels to pictures. Spontaneous interactive imaging might also have occurred either on a syntactic or conceptual level.

The interactive illustrations also provided the opportunity for dual coding since the first and fourth panels were identical to pictures used in the non-interactive condition. The semantic aspect of the two types of visuals did not differ. However, the interactive illustrations had the potential for leading to additional imaginal processing through the intermediate panels, though verbal encoding probably would not have taken place with the middle panels given their metamorphic states. Presumably the key to their facilitation lies in this extra pictorial emphasis provided by a progressively changing visual link.

Levin (1981) described thedifference between theprocessingof images and illustrations by referring to the need for cognitive constructions and elaborations for the former and visual perception and interpretation for the latter. Theoretically, progression bridges the gap between images that must be formulated internally and illustrations that are provided externally The intermediate panels act as a purely visual link between two items, but this link is lacking a semantic component. This external variable acts as a driving mechanism for the internal variable; that is, the viewer is encouraged by the visual link to create some semantic link to strengthen the association on another level. Hence all the skills which Levin refers to are coming into play First visual perception and interpretation must occur (illustration activity), followed by cognitive constructions and elaborations (imagery activity).

For these processes to occur, an interactive illustration is necessary but not sufficient. The illustration must also stimulate the viewer to think about the

association being made, as is the case with visual puns and progression. A simple spatial or active relationship is also interactive (and clearly facilitative, as research has shown), but this provides all the necessary information. If everything is immediately available to the learner, then storage can take place with less cognitive activity. Presumably a greater degree of cognitive involvement with information should make that information more accessible later, as Craik and Lockhart (1972) and Lockhart and Craik (1990) have suggested. This is the premise on which advertisers work that makes their profession so successful, and future research could explore this topic by comparing memory capacity given standard interactive illustrations (subject-object) and cognitively complex interactive illustrations.

Theoretically, then, complex interactive illustrations are facilitative because they initially capture the attention and interest of the learner because of their distinctiveness and highly engaging qualities. They maintain this level of attention by actively involving the learner in deciphering the message. This essential step in communicating a visual message must be achieved for ultimate memorability.

Another important aspect of this theory deals with the reliability issue. Levin (1981) pointed out that illustrations are more reliable for memory than images. Progression, like visual puns, provides the reliability of an illustration, but also allows for the unique aspect of individuality that makes imagining a successful mnemonic technique. A learner's memory is enhanced by his or her own experiences.

One illustration approach which has considered these criteria is the transformation approach (see Levin, Anglin, & Carney, 1987 for more details), studied mainly in prose-learning situations. Transformations provide a mnemonic strategy for learning a large amount of factual information by creating both an interactive visual and auditory association between familiar and unfamiliar bits of information. The focus is on connecting critical features. As Levin et al. pointed out, this type of illustration is singular in its omission from traditional textbooks.

Progressive illustrations can make an impact in educational settings simply because of their memorability. They have the capacity for achieving an affective change, which is useful for some content. For instance, in a lecture or chapter dealing with environmental issues a smokestack could progressively transform into a tree to stress the need for environmental regulation of industries. While this visual would not contain the specific content, it could provide supportive emotional appeal. Similarly, progressive illustrations could be used for factual content. Indeed, ***Sesame Street*** has used the technique of progression to associate letters with words, as in b progressively changing to ***ball.***

The arrival of the new information age has ushered in new tools and technologies that are rapidly redefining the way learning and communication occur. For example, hypermedia could provide the basis for using progressive illustrations to drive a point. Referring back to the ecological example, the

students could be prompted to click continuously on the image of a smokestack in order to watch it gradually change to a tree to make a point regarding clean air. Alternatively progression might be used in animation graphics where the learner would select a symbol representing some issue (i.e., a smoke stack) and through animation the image would change to a contrasting symbol (i.e., tree).

A final point should be made with reference to the hypothesis that the 3-panel progression group would have poorer scores than the 4-panel progression group. Fleming and Levie (1978) discussed a perception principle called closure, in which the viewer completes stimulus figures which are open or incomplete. They provide evidence of the viewer's ability to perform this task, but indicate also that unfamiliar or ambiguous stimuli may prove difficult. The present stimuli were indeed unfamiliar, but the lack of difference between scores for the two progression groups suggests that subjects were able to provide the necessary closure anyway even without all the cues. Even a partial transformation was better than none at all.

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APPENDIX

Stimulus Pairs

1. Africa-Skull
2. Table-Spider
3. Fig leaf-Trousers
4. Watering can-Elephant
5. Dog-Bowling pin
6. Shark-Sailboat
7. Globe-Beagan/Gorbachov
a. Heart-Bomb
9. Communist symbol-Question mark
10. Treble clef-Violin
11. Elephant and donkey-Mickey Mouse
12. Book-Computer
13. Gun-Bread
14. Jet-Butterfly
15. Smoke stack-Tree
16. Crane-Dinasaur
17. Turtle-Car
18. Bat-Umbrella
19. Food-Television
20. Cat-owl
21. Peace sign-Nazi
22. Globe-headphone
23. Brain-Bulb
24. Soccer-Italy

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