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The Transfer of multimodal vs. unimodal prototypes

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The transfer of multimodal vs. unimodal prototypes

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San Jose State University, 1992

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THE TRANSFER OF MULTIMODAL VS. UNIMODAL PROTOTYPES

A Thesis

Presented to

The Faculty of the Department of Psychology

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

by

Donna M. Davilla

May, 1992

APPROVED FOR THE DEPARTMENT OF PSYCHOLOGY

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ABSTRACT

THE TRANSFER OF MULTIMODAL VS. UNIMODAL PROTOTYPES

by Donna M. Davilla

A prototype is the ideal member of a category of objects or events. The present study was designed to investigate the transfer of multimodally formed/recognized prototypes by contrasting multimodally formed/recognized prototypes with unimodally formed/recognized prototypes. Subjects in the experiment were 108 San Jose State University students. These subjects were presented geometric stimuli in either the unimodal visual, unimodal kinesthetic or multimodal visual/kinesthetic modalities during acquisition and recognition stages of the experiment. All possible combinations of presentation types for acquisition and recognition formed the nine transfer conditions in the experiment. A partial replication of previous research was achieved in intra-modal unimodal conditions. The key finding of the present experiment is that strong prototype formation seems to occur in circumstances in which less specific exemplar information is transferred and weak prototype formation seems to occur under circumstances where more specific exemplar information is transferred.

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The Transfer of Multimodal Vs. Unimodal Prototypes

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Running head: MULTIMODAL VS. UNIMODAL PROTOTYPES

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Abstract

A prototype is considered to be the ideal member of a category of objects or events. There is a large body of research that has concentrated on the intra-modal and cross-modal transfer of unimodally formed/recognized prototypes. However, the transfer of multimodally formed/recognized prototypes have yet to be explored. The present study was designed to explore this issue by contrasting multimodally formed/recognized prototypes with unimodally formed/recognized prototypes. The subjects in the experiment were 108 San Jose State University students. These subjects were presented geometric stimuli in either the unimodal visual, unimodal kinesthetic or multimodal visual/kinesthetic modalities during acquisition and recognition stages of the experiment. All possible combinations of the three presentation types for acquisition and recognition formed the nine transfer conditions in the experiment. A partial replication of previous research was achieved in the intra-modal unimodal conditions. The key finding of the present experiment is that strong prototype formation seems to occur in circumstances in which less specific exemplar information is transferred and weak prototype formation seems to occur under circumstances where more specific exemplar information is transferred.

The Transfer of Multimodal Vs. Unimodal Prototypes

Historical Background

Cognitive psychologists and philosophers have sought to reveal the mechanisms involved in the production of memory representations by formulating questions about the nature of representation and investigating them. Questions leading to the development of prototype theory and other theories of abstract memory representation date back as far as Aristotle (see Posner & Keele, 1968). Aristotle questioned what learning allows a person to correctly recognize a particular animal, such as a dog, that has never been seen before. According to Posner and Keele (1968), the philosophical idea of abstract representations was introduced to modern psychology through Bartlett's 1932 work on schema formation. It appears that this work may have provided the initial thrust toward the formation of prototype theory by causing a chain reaction of thought and experimentation in the following decades.

A Prototypical Prototype Study

Solso and McCarthy (1981) sought to evaluate the prototype formation of complex visual stimuli and to examine the persistence of memories for prototypes and exemplars. Sixty undergraduate students served as subjects in the experiment; thirty-six in condition 1 and twenty-four in condition 2. The prototype faces and exemplars used in the experiment were created with an Identikit II. An Identikit II is a face identification device used in police work that consists of a series of plastic templates, each representing a facial characteristic. The faces generated for the experiment varied on four facial features: hair, eyes, nose, and chin+mouth. Non-prototypical exemplars were created that shared either 75, 50, 25 or 0 percent of the features of the prototype. During an acquisition phase, subjects in both conditions were allowed to view 10 exemplar faces for 10 s each with instructions to try to memorize them. Three of the ten faces were 75% exemplars, four were 50% exemplars and the last three were 25% exemplars. Subjects in Condition 1 were

given a five minute distracter task before the recognition phase of the experiment while subjects in condition 2 were given a six-week delay before the recognition phase took place. In the recognition phase, the previously unseen prototype was shown to the subjects along with four new (previously unseen) exemplars and three old (previously seen) exemplars. The subjects were asked to classify these faces as either new or old and to estimate their confidence in the classification on a scale of one to five. The new/old classifications were converted to -/+s respectively and combined with the confidence ratings. The purpose in combining the classifications with the confidence ratings was to arrive at a single set of ratings for analysis. This set of ratings reflects the relative confidence of subjects in their classifications of stimuli. An analysis of the data for both conditions revealed high positive confidence ratings for the prototypes. Thirty-five of 36 subjects in Condition 1 and 23 of 24 subjects in Condition 2 falsely recognized the prototypes as old items, even though they had not been previously seen. Yet, at the same time they were successful in distinguishing between the other new and old items.

Research on prototype theory has recently begun to look at the cross-modal transfer of prototypes, that is, how prototypes formed in one modality are recognized in another. Questions have been raised concerning how prototypes are formed in separate modalities. Does each modality form prototypes in the same way and what information is transferred from one modality to another?

Cross-Modal Transfer

Cross-modal transfer is the transfer of information from one modality to another modality. Many studies on cross-modal transfer have utilized line-length matching tasks. In general, these studies have found intra-modal transfer to be superior to cross-modal transfer (Kelvin & Mulik, 1958; Connolly & Jones, 1970; Reeve, Mackey & Fober, 1986). Intra-modal transfer is the transfer of information within a single modality. In a study by Reeve et al. (1986), subjects were trained in the kinesthetic modality to move a

linear positioning-slide apparatus to a criterion location. In feedback conditions, the subjects were asked to reposition the handle in the criterion location that they had learned in training. Some subjects received feedback in only the kinesthetic modality, while others received feedback in both the kinesthetic and visual modalities. The results showed that subjects who were in the kinesthetic intra-modal feedback condition were significantly more accurate than subjects who were in kinesthetic-visual cross-modal conditions.

Although these results favor intra-modal transfer over cross-modal transfer, it has been noted (Millar, 1981) that cross-modal deficits are common in matching studies using lines as stimuli when compared to similar studies using shapes as stimuli. Studies using shapes as stimuli have had much more success with cross-modal transfer (Rudel & Teuber, 1964; Solso & Raynis, 1982; Solso, Oppy, & Mearns, 1987).

It may be that the type of stimulus plays an important role in the success of cross-modal transfer. According to Gibson (1969), discriminations are made on the basis of distinctive details that are probably two-dimensional invariants of the stimulus that stand out to make a pattern unique. Following this reasoning, Gibson suggests that length judgments are more difficult cross-modally because unidimensional stimuli provide fewer of the higher-order properties that make the pattern unique. The unidimensional properties of straight lines are simpler than the multidimensional properties of many free-form or complex shapes (Abravanel, 1981). Consequently, compared to shapes, single lines provide fewer of the higher-order properties that may be crucial to cross-modal transfer. That is not to say that it is impossible to find superior cross-modal transfer in line length matching tasks. In fact, Crabtree and Crabtree (1987) found that cross-modal matching was enhanced by multimodal experience for distances shorter than the training distance.

The immediate study is designed to compare the cross-modal transfer of multimodally and unimodally formed prototypes. The studies cited in the previous paragraphs provide a general background to the area of cross-modal transfer, a background

that seems to indicate that findings of cross-modal equivalence are not promising. However, one must be careful not to over-generalize the findings of these studies to the experiment at hand. The issue is a complicated one. The task in the present experiment does not merely call for a matching of one stimulus to another, but calls for recognition ratings of individual stimuli based on an entire set of stimuli presented prior to the recognition phase of the experiment. Some of the stimuli in the recognition phase will have been previously seen in the training phase but others, including the prototype, will not have been previously seen.

Cross-Modal Equivalence In Prototype Formation

Previous findings in cross-modal studies of prototype formation indicate not only that cross-modal equivalence is possible, but also that cross-modal transfer may be enhanced by multimodal experience. There is some evidence indicating that prototypes are coded in similar ways within separate modalities. Williams and Aiken (1977) studied prototype formation in the auditory and visual modes and concluded that common strategies were used in pattern classification across modalities based on the consistency of right and wrong classifications made by subjects at all age levels. Later, Solso and Raynis (1979) studied the prototype formation of geometric figures presented visually, kinesthetically, and imaginably to determine if prototypes formed in one modality would resemble prototypes formed in another modality. They found that prototypes formed with the same geometric stimuli were rated similarly in different modalities. On the basis of these results, Solso and Raynis concluded that, "The internal representation of similar geometric forms is similarly coded, independent of the modality in which the forms are originally perceived" (Solso & Raynis, 1979, p. 711).

Cross-Modal Information Transfer

Solso and Raynis (1982) provided some insights into the information transferred from one modality to another. They examined the cross-modal transfer of prototypes

among the visual, tactual, and kinesthetic modalities. In this study, geometric figures consisting of three connected line segments were used as stimuli (see Figure 1). The stimuli set was developed by creating a base figure, the prototype, and then permuting the prototype figure to generate exemplar figures that vary in similarity to the prototype. In acquisition, the stimuli were presented to the subjects either visually, tactually, or kinesthetically and then transfer data was collected from recognition tests in either the same modality or in one of the other two. The results indicated that although the prototype was falsely recognized as an old item in the transfer conditions, it was not recognized with as much confidence as some old items that were close in appearance to the prototype. This pattern of results, where old items that are close in appearance to the prototype are recognized with greater confidence than the prototype, while the less prototypical old items and new items are not recognized as well as the prototype, is reported in several other studies (Solso & Raynis, 1979; Solso, Ament, Kuraishy & Mearns, 1986; and Solso, Oppy & Mearns, 1987). The tendency for this pattern of results to emerge repeatedly is not surprising; it is likely to be related to the transfer of specific exemplar information. Less distorted exemplars, which have been determined to be closer in appearance to the prototype than more distorted exemplars (Solso & Raynis, 1982), seem to facilitate the transfer of specific exemplar information between modalities. The ease with which specific information about these exemplars is transferred makes them more recognizable than the prototype. They are close in appearance to the prototype and have been seen previously.

Specific Exemplar Information

The amount of specific exemplar information that is transferred and retained for recognition may be somewhat dependent on the level of exemplar distortion from the prototype. Several findings are relevant to this view. First, it has been found that the perceived distance of an exemplar from the prototype increases with the level of exemplar distortion from the prototype (Posner, Goldsmith, & Welton, 1967; Franks & Bransford,

Figure 1. Series 1 set of geometric figures (adapted from Solso and Raynis, 1979).

1971). Second, the level of exemplar distortion is systematically related to the rate of prototype learning (Posner, et al 1967; Peterson, Meagher, Chait, & Gillie, 1973; Medin & Smith, 1984). The more distorted exemplar patterns are, the longer it takes to learn the prototype for the category. Third, the correct classification of novel patterns increases as the distortion of exemplars decreases (Posner & Keele, 1968; Mervis & Rosch 1981; Homa, Cross, Cornell, Goldman, & Schwartz, 1973; Homa & Vosburgh, 1976; Aiken & Williams, 1973; Williams & Aiken, 1977); so, the closer a novel pattern is to the prototype, the easier it is to classify. Fourth, the false recognition of prototypes and the degree of confidence of the false recognition are negatively correlated with the degree of distortion from the prototype (Franks & Bransford, 1971; Neumann, 1974, 1977; Posnansky & Neumann, 1976). In other words, subjects falsely recognize previously unseen prototypes more often and with greater confidence when the distortion of the acquisition exemplars is low. Taken as a whole, these findings imply that the closer the exemplars and the prototype are in form, the more likely they are to have a mutually beneficial relationship; that is, they are more likely to facilitate the transfer of specific exemplar information and encourage highly confident recognition ratings for both the prototype and less-distorted exemplars. In fact, Solso and Raynis (1982) found that the transfer of specific exemplar information for less distorted, old exemplars seem to be somewhat stronger than the prototype formed. In a majority of the experimental conditions, subjects were more confident that they had seen the least-distorted old exemplars than the prototype. Close proximity to the prototype and prior exposure to the least-distorted old exemplars made them more likely to be classified as old items than the prototype. As further evidence for the dependency of distortion on the transfer of specific exemplar information, subjects were equally likely to report that they had seen the previously unseen prototype as they were to report that they had seen the more distorted, old exemplars. This finding is probably the result of a trade-off between proximity to the

prototype and the memory trace created by prior exposure to the more-distorted, old exemplars.

Effect Of Time On The Retention Of Specific Exemplar Information

Of course, over time this complex relationship between the exemplars and prototype may break down. Previous research has shown that the ability to recognize and classify old exemplars declines substantially over time (Hintzman & Ludlam, 1980; Strauss, 1979; Homa et al., 1973; Posner & Keele, 1970; Strange, Kenney, Kessel, & Jenkins, 1970; Solso & McCarthy, 1981). It appears that over time, as specific exemplar information is lost, the prototype has the advantage of being close in appearance to all the old original exemplars, rather than being identical to only one. Consequently, the prototype appears to be more robust than the specific exemplar information that is initially stored during acquisition. This ability to recognize the prototype after long periods of time passage has been coined "pseudomemory" by Solso and McCarthy, (1981).

Implications

The present experiment will provide some indication of whether or not further research should be conducted to determine if simulator training, aimed at building prototypes, would be beneficial in environments such as aviation, that require individuals to take in and respond to information multimodally. The present experiment will determine if there is an advantage of multimodally formed/recognized prototypes of stimuli somewhat more complex than straight-lines, but not as complex as situations. In an aviation environment, pilots must set priorities and goals, organize time and resources, and decide where, when, and how to allocate attention and effort (NASA/USAF, 1991). According to NASA/USAF, it is these "strategic behaviors" that directly determine pilot actions. If a pilot is to engage in appropriate "strategic behaviors," then the pilot's assessment of the current situation is critical. With the aforementioned information in mind, it seems logical to conclude that if the data from this experiment indicate that multimodal prototypes are

stronger and more successful in transfer than unimodal prototypes, then further research might be warranted to determine if pilot training programs might benefit from increased multimodal experience in the form of additional flight simulator training that is aimed at developing strong situational prototypes. Essentially, a flight simulator that would provide pilots with specific situational information as well as respond with a high degree of realism to pilot actions, would provide pilots with multimodal information with which they could build a prototype. Once the pilot is faced with a potentially hazardous situation in real-life, he or she can draw upon this situational prototype to avoid harm. Experience plays a major role in pilot competence (Bennett, Schwirzke, & Harms, 1990). The formation of situational prototypes in training may help to equate less-experienced pilots with more-experienced pilots who did not have the benefit of forming such situational prototypes in training. It would be interesting to explore this difference in future research.

Hypotheses

As previously stated, the present experiment will focus on the transfer of multimodal prototypes compared to unimodal prototypes. It is interesting to consider what effect the multimodal transfer of prototypes will have on recognition as compared to the unimodal transfer of prototypes. Since the research on specific exemplar information previously cited clearly implies that the closer the exemplars and the prototype are in form, the more likely they are to facilitate the transfer of specific exemplar information and encourage highly confident recognition ratings for both the prototype and less-distorted exemplars, it would follow that more specific exemplar information would result in stronger prototype formation. If more specific exemplar information is transferred in multimodal conditions, then prototypes formed/recognized in multimodal conditions would be expected to be stronger than prototypes formed/recognized in unimodal conditions. Because of the nature of multimodal stimulus presentation, subjects in these conditions will

have more specific exemplar information on which to base their false acceptance of the prototype as an old item than subjects in unimodal conditions.

If it proves to be the case that multimodal presentation enhances prototype formation by providing a greater amount of specific exemplar information than unimodal presentation, then memory for specific exemplars from acquisition will also be likely to be enhanced in multimodal conditions. In multimodal conditions, we would expect to find a distinct cut-off in ratings between new and old stimuli, instead of the linear trend that has been typically observed in unimodal studies; this would be expected since subjects in multimodal conditions will have more information on which to base their classification of new and old stimuli.

Method

Subjects

Nine groups of 12 subjects each participated in the experiment. To form the nine groups of subjects, a total of 108 students enrolled in psychology courses at San Jose State University were recruited. These subjects were randomly assigned to treatment conditions and run individually. All subjects received course credit for their participation.

Stimuli and Apparatus

The series 1 set of geometric figures described by Solso and Raynis (1979, see Figure 1) served as the experimental stimuli. The geometric figures consisted of three connected line segments derived from permutations of a base figure, or prototype. The permutations of the prototype, the exemplars, ranged from very similar to very dissimilar from the prototype. The acquisition set consisted of 10 exemplars. The prototype figure was not in the acquisition set. The recognition set consisted of eight stimuli: the prototype (previously unseen), four new exemplars (previously unseen), and three old (previously seen) exemplars. The validity of the defined prototype for the stimuli set is an issue central

to the methodology of the stimuli set development; for a discussion of the method used to construct the stimuli set see Solso and Raynis (1979).

Plastic guides were used in the presentation of both visual and kinesthetic stimuli. In kinesthetic conditions a stylus and stimulus box were also used with the guides. The purpose in using the stylus/plastic guides was to keep consistency in hand and arm movements during kinesthetic conditions. The plastic guides consisted of pieces of plastic with the stimuli cut out of the plastic (like a stencil). The stylus served the purpose of guiding the subject through the path of the stimulus cut out of the plastic and the stimulus box served the purpose of blocking the stimulus from view.

The dimensions of the stimulus box were be 10" x 12" x 9 3/4" with some slight variations (see Figure 2). The dimensions of the top of the box were 10"x18", resulting in an 8" overhang that was designed to obstruct the subject's view of the stimulus. Black cloth was attached to the sides of the 8" overhang to further insure obstruction of the subject's view. A 4" opening in the front of the box allowed subjects to reach into the box. The back of the box was completely open to allow the experimenter easy access for switching stimuli. Additionally, on the bottom inside of the box there were 1/4" blocks of wood arranged to provide an 8"x8" space that stimuli could be slid into and out of.

Design

This experiment employed a 3x3 between-subjects factorial design, with three levels of stimulus presentation for the acquisition phase and three levels of stimulus presentation for the recognition phase of the experiment (see Figure 3). The three levels for both presentation phases were visual, kinesthetic and visual/kinesthetic. A total of nine conditions were derived from all the possible combinations of the two variables.

Procedure

As previously mentioned, there were three levels of stimulus presentation in the acquisition phase and three levels of stimulus presentation in the recognition phase of the

Figure2. Drawings of stimulus box. Drawings not to scale.

		Recognition		
		visual	kinesthetic	vis/kin
Acquisition	visual	V - V	V - K	V - V/K
	Kinesthetic	K - V	K - K	K - V/K
	vis/kin	V/K - V	V/K - K	V/K - V/K

Figure 3. 3 X 3 between subjects factorial design

experiment: visual presentation, kinesthetic presentation, and visual/kinesthetic presentation. Regardless of condition, approximately one hour was required to collect data from each subject.

Visual Presentation

Acquisition. In acquisition, subjects were seated at a table and told that the task involved learning some geometric figures that would be presented one at a time and that after all the figures had been presented once, they would be presented a second time to facilitate learning. The presentation order of the stimuli in the in the second acquisition trial followed the same sequence as in the first acquisition trial. However, the sequence in which the stimulus set was initially presented to each subject was randomized. All trials consisted of the sequential display of each stimulus from the set for 15 s per presentation with an inter-stimulus interval of 5 s. The display time was monitored by the experimenter through the use of a stop watch. Once acquisition was complete, the subjects were given a 5 minute break before the recognition phase of the experiment.

Recognition. Prior to beginning the recognition phase of the experiment, subjects were seated at the table and informed that a visual recognition test would be given based on the stimuli presented in the first part of the experiment. The form of presentation was explained and demonstrated to the subject prior to beginning the recognition phase in all conditions of the experiment regardless of whether the type of stimulus presentation was the same as in acquisition. The stimulus used to demonstrate the form of presentation in recognition, a half-circle, was dissimilar to the prototype and exemplars so as not to confound the experiment.

In the recognition phase, recognition ratings were collected from the subjects. There was only one trial in recognition. As each stimulus from the recognition set was displayed, the subject was asked to respond "new" or "old," indicating whether or not they believed that they had previously seen or been exposed to the geometric figure presented. The

subject was allowed to view each stimulus until a response was made. The subject was also asked to give a confidence rating for their answer on a scale of 1 to 5, five being most confident and one being least confident. The experimenter recorded the subject's verbal responses on an answer sheet following the methodology of Solso, Oppy, and Mearns (1987). A "+" was recorded for each "old" response and a "-" for each "new" response. The confidence ratings were recorded as they were reported by the subjects; this rating structure resulted in a possible value range of +1 to +5 for "old" judgments and -1 to -5 for "new" judgments. These ratings served as an accuracy measure for subject performance. The new/old (+/-), rating provided an absolute measure of accuracy, while the confidence level (1-5) provided a relative measure of the degree to which subjects were accurate.

The procedure described above was followed as closely as possible in all acquisition and recognition conditions; any exceptions are noted in the following paragraphs.

Kinesthetic Presentation

Acquisition. Since the stimuli in kinesthetic presentation conditions were presented in the kinesthetic modality alone, the subject was seated at the table with the stimulus box placed in front of him/her before the experiment. The subject was then instructed to reach his/her hand through the opening in the box and was given a stylus to hold in his/her dominant hand. The experimenter led the subject's stylus into the plastic cut out guide at the beginning of the stimulus path. Once the stylus was positioned, the subject was instructed to move it through the cut out stimulus path. When the subject reached the end of the path, the experimenter immediately led the subject's stylus back to the beginning of the stimulus path and told the subject to move the stylus through the cut out path again; this was repeated once more, resulting in a third exposure to the stimulus during acquisition. The purpose of the third exposure to the stimulus in kinesthetic only presentation conditions was to equate for stimulus exposure time between kinesthetic only stimulus presentation

and conditions involving visual stimulus presentation. The kinesthetic only stimulus presentation procedure described above was repeated for all the stimuli and took 20 to 30 s per stimulus.

Recognition. In kinesthetic recognition conditions, the stimuli were presented in the same manner as in kinesthetic acquisition conditions, except that each stimulus was presented to the subject for as long as was needed, until the subject had classified the stimulus as "old" or "new" and given it a confidence rating.

Visual/Kinesthetic Presentation

Acquisition. In this condition each of the stimuli were presented simultaneously in the visual and kinesthetic modalities. Subjects were allowed to view the plastic guide while moving the stylus through the cut out path of the stimulus guide.

Recognition. In visual/kinesthetic recognition conditions, the stimuli were presented in the same manner as in visual/kinesthetic acquisition conditions, except the subject was allowed to view each stimulus and move the stylus through the cut out path, until a response was made. However, in this condition, subjects were required to experience the stimuli kinesthetically at least once before making a response. This requirement was designed to prevent the subjects from making responses based on the visual presentation of the stimuli alone. For those subjects in the visual/kinesthetic recognition condition who were presented the acquisition stimuli in a modality other than visual/kinesthetic, the form of presentation was explained and demonstrated prior to beginning the recognition phase.

Results and Discussion

The purpose of this study was two fold. The first purpose was to evaluate under what conditions prototypes are formed and recognized. The second was to explore the concept of multimodal prototype formation and recognition as related to previous literature from the areas of prototype formation and cross-modal transfer. It was hypothesized that if

more specific exemplar information is transferred multimodally than unimodally, then prototypes formed/recognized multimodally would be stronger than prototypes formed/recognized unimodally. A second hypothesis stated that if prototype formation is enhanced in multimodal conditions by the transfer of specific exemplar information, then memory for specific exemplars from acquisition would also be enhanced in multimodal conditions. If true, the second hypothesis would manifest itself by causing a distinct cut-off in ratings between new and old stimuli in multimodal conditions, instead of the linear trend that has been typically observed in unimodal studies.

For statistical analysis, the confidence ratings (-5 to +5) were converted to a range of 1-10. Scores above five indicated that the stimulus was identified as "old," while scores five and below indicated that the stimulus was identified as "new". The distance of the rating from five indicated the degree to which subjects were confident of their classification of the stimulus as a "new" or "old" item. The scores farthest away from 5 indicated the greatest confidence.

A close inspection of the data made it apparent that stimulus number 17 was an outlier in the data set of this experiment (see Figure 4). It may have also been a problematic item in the data set of Solso and Raynis (1982) (see Figures 5 and 6). The figures indicate that stimulus number 17 received confidence ratings in the opposite direction than expected; this is likely to be due to its similarity to stimulus numbers 14 and 5, which were old items. Many subjects verbally expressed their confusion over these items during recognition. Because of this contamination of the data set, stimulus number 17 was removed for all further analyses, with the exception of those analyses directly comparing the present experiment with previous research that used the same stimulus set.

Comparison among the nine conditions

A 3 (acquisition) x 3 (recognition) x 7 (stimuli) x 12 (subjects) mixed analysis of variance with stimuli as a within subjects factor was performed on the confidence ratings

Figure 4. Mean Confidence Ratings of Acquisition Groups.

Figure 5. Intra-modal Group Results of Present and Previous Research*.

*Previous results adapted from Solso & Raynis (1982)

Figure 6. Cross- modal Group Results of Present and Previous Research*.

*Previous results adapted from Solso & Raynis (1982)

(see Table 1). Significant main effects of acquisition and of stimuli were found. The significant main effect of acquisition, $F(2, 99) = 124.99, p < .001$, indicates that subject recognition ratings were significantly effected by the type of acquisition received (see Figure 7). The significant main effect of stimuli, $F(6, 594) = 490.75, p < .001$, indicates that in general, old stimuli ratings were reliably different from new stimuli ratings. The analysis of variance further revealed a significant interaction between acquisition and recognition conditions, $F(4, 99) = 26.63, p < .05$. The presence of an interaction here indicates that the effect of acquisition changes at different recognition conditions. This interaction reflects both the intra-modal/cross-modal and the unimodal/multimodal differences between groups. Generally, across the three levels of both acquisition and recognition subject ratings differed as a direct result of the type of stimulus presentation. These differences are attributable to either or both intra-modal versus cross-modal stimulus presentation and unimodal versus multimodal stimulus presentation. The analysis of variance also found significant two way interactions between stimuli and acquisition, $F(12, 594) = 33.42, p < .001$, and between stimuli and recognition, $F(12, 594) = 27.18, p < .001$. These interactions verify that subjects rated stimuli significantly different dependent on the type of acquisition alone and dependent on the type of recognition alone. The most informative result of the analysis was a significant three way interaction between stimuli, acquisition, and recognition, $F(24, 594) = 20.82, p < .001$. This three way interaction means that subject stimulus ratings varied reliably at different levels of acquisition and recognition. Accuracy rates of acquisition and recognition groups were investigated to identify how stimulus ratings differed based on these variables.

Investigation of acquisition and recognition group accuracy

In general, the accuracy rates demonstrate that the groups receiving visual and visual/kinesthetic acquisition or recognition were highly accurate while the kinesthetic groups exhibited chance level performance in most cases (see Figures 8-10). In many

Source	SS	DF	MS	F
(Between subjects)				
Acquisition (Acq)	249.97	2	124.99	11.58***
Recognition (Rec)	55.64	2	27.82	2.577
Acq X Rec	106.51	4	26.63	2.466*
Error	1068.73	99	10.80	
(Within subjects)				
Stimuli	2944.51	6	490.75	64.119***
Acquisition (Acq) X Stimuli	401.05	12	33.42	4.367***
Recognition (Rec) X Stimuli	326.10	12	27.18	3.551***
Acq X Rec X Stimuli	499.70	24	20.82	2.720***
Error	4546.36	594	7.654	
Total	10198.57	755		

***=.001, **=.01, *=.05

Table 1. Mixed Design 3 x 3 x 7 x 12 Analysis of Variance Summary Table

Figure 7. Mean Confidence Ratings for Acquisition Groups without stimulus #17

Figure 8. Accuracy Rates of the Visual Acquisition Groups.

Figure 9. Accuracy Rates of the Kinesthetic Acquisition Groups.

Figure 10. Accuracy Rates of the Visual/Kinesthetic Acquisition Groups.

cases the performance of the visual and visual/kinesthetic recognition groups were equivalent at the same level of acquisition. For example, the visual-visual and visual-visual/kinesthetic groups were equally accurate in their ratings of old items (see Figure 8). Additionally, the visual and visual/kinesthetic recognition groups which received visual/kinesthetic acquisition were equally accurate in their ratings of new items (see Figure 10). In instances where differences in accuracy were exhibited by the visual and visual/kinesthetic groups the increase in accuracy tended to show up in the intramodal transfer groups regardless of unimodal or multimodal presentation (see Figures 8-10). This may indicate that intramodal transfer is more accurate regardless of the unimodal or multimodal presentation of stimuli. This issue will be examined separately later.

Accuracy rates of visual acquisition groups

In general these groups were highly accurate in their ratings of the prototype, old and new items (see Figure 8). Visual-visual and visual-visual/kinesthetic groups were highly accurate in their ratings. Only the visual-kinesthetic group ratings were poor. They were at chance levels for the prototype, old and new items (see Figure 8).

Accuracy rates of kinesthetic acquisition groups

The kinesthetic acquisition groups were consistently inaccurate in their ratings of the prototype (see Figure 9). All of these groups were highly confident that they had seen the prototype before even though they had not. In fact, these groups formed the strongest prototypes of all the conditions and provide the greatest evidence for prototype formation. Although these groups varied in their accuracy of ratings for old and new items, they were consistently inaccurate in their ratings of the prototype. Ratings for old items were above chance level accuracy for the most part, however the ratings for new items, revolved around chance levels of accuracy.

Accuracy rates of visual/kinesthetic acquisition groups

The groups that received visual/kinesthetic acquisition were not very accurate in

their ratings of the prototype (see Figure 10). Only the visual/kinesthetic-kinesthetic group was above chance level in their accuracy of rating the prototype as a new item. While their accuracy in rating the prototype was poor, the visual/kinesthetic-visual and the visual/kinesthetic-visual/kinesthetic groups were highly accurate in their old and new item ratings. Alternatively, the visual/kinesthetic-kinesthetic group ratings were mostly around chance levels for the new and old stimuli.

The successful transfer of specific exemplar information is demonstrated by high accuracy in rating new and old items. The error rates revealed that kinesthetic acquisition groups formed the strongest prototypes and were the very inaccurate in rating the old and new stimuli. The error rates also revealed that the visual and the visual-kinesthetic groups formed the weakest prototypes and were highly accurate in rating old and new items. It appears that strong prototype formation occurs where less specific exemplar information is transferred and weak prototype formation occurs where more specific exemplar information is transferred.

Comparison of multimodal and unimodal conditions

In these further analyses, only the unimodal visual and multimodal visual/kinesthetic groups were examined in order to identify clearly the differences between the transfer of prototypes/stimuli unimodally versus multimodally. Despite high confidence ratings for the prototype, the error rates of the groups which received kinesthetic only acquisition or recognition show chance level performance for all the old and new stimuli ratings. Therefore, the groups receiving unimodal kinesthetic acquisition or recognition were not included in these analyses because of the consistently inaccurate performance in the discrimination of new and old stimuli relative to the unimodal visual and multimodal visual/kinesthetic groups (see Figures 8-10). Without the almost chance level kinesthetic data, the differences between unimodal and multimodal acquisition/recognition become clearer.

The mean ratings collected revealed that overall, subjects in all four groups (visual-visual, visual-visual/kinesthetic, visual/kinesthetic-visual and visual/kinesthetic-visual/kinesthetic) were able to accurately discriminate between old and new items other than the prototype (see Table 2). However, of the four groups, only the two groups receiving multimodal acquisition had a tendency to rate the prototype as an old item (see Figure 11). This finding is suggestive of stronger prototype formation in multimodal acquisition than unimodal acquisition.

Assessing the strength of prototype formation

In an effort to address the issue of strength of prototype formation, a t-test comparing the prototype ratings of multimodal versus unimodal groups was conducted. The difference in mean prototype ratings between the two multimodal groups and the two unimodal groups exhibited only marginal statistical reliability $t(46)=-1.654, p<.10$. Although the difference between unimodal and multimodal mean prototype ratings is only marginally significant, a close inspection of these ratings reveals a trend toward stronger prototype formation in the multimodal visual/kinesthetic acquisition groups (see Figure 12). The error rates lend some support to this trend. The visual/kinesthetic acquisition groups were consistently less accurate in their ratings of the prototype than the visual acquisition groups (see figures 8 & 10). Considering that only the multimodal acquisition groups rated the prototype as old and that there appears to be a distinct, although marginally reliable, trend toward stronger prototype formation in multimodal acquisition groups, it seems appropriate to conclude that in some instances, multimodally formed prototypes are somewhat more likely to be mistakenly categorized as old items than unimodally formed prototypes. It should be noted however, that the strongest prototype formation occurred in the unimodal kinesthetic acquisition groups.

Transfer of specific exemplar information

It was concluded from the error rate data that strong prototype formation seems to

Group	Means and Standard Deviations						t tests		
	$\bar{X}$ Proto	sd	$\bar{X}$ Old	sd	$\bar{X}$ New	sd	P vs. Old (df=11)	P vs. New (df=11)	New vs. Old (df=11)
V-V	4.2	3.0	9.0	2.3	1.7	1.2	-4.4***	3.3**	15.4***
V-V/K	4.1	3.2	8.9	2.3	2.6	2.5	-5.0***	2.0	8.5***
V/K-V	5.3	3.6	9.1	2.2	3.3	3.2	-3.1**	1.6	6.3***
V/K-V/K	6.2	3.6	8.7	2.3	3.4	3.0	-2.6*	2.0	9.3***
***=.001, **=.01, *=.05									

Table 2. Means, Standard Deviations and t-tests for the Unimodal Visual and Multimodal Visual/Kinesthetic Groups.

Figure 11. Mean Stimuli Ratings for the Unimodal Visual and Multimodal Visual/Kinesthetic Groups.

Figure 12. Mean Prototype Ratings for Unimodal Visual and Multimodal Visual/Kinesthetic Groups.

occur where less specific exemplar information is transferred and weak prototype formation seems to occur where more specific exemplar information is transferred. It was also noted that the visual and visual/kinesthetic groups were equally and highly accurate in their ratings of stimuli. It was later concluded that in some instances multimodally formed prototypes are somewhat more likely to be mistakenly categorized as old items than unimodally formed prototypes. When taken as a whole these findings could imply that the multimodal formation of prototypes may be unique in that it allows for concurrent prototype formation and retention of specific exemplar information. The evidence for this is marginal at best.

A trend analysis was conducted to evaluate the transfer of specific exemplar information. For the trend analysis the stimuli were ordered from 11, the prototype, through 18, the new item least similar to the prototype. The trend analysis was done in an effort to test the hypothesis that memory for specific exemplars from acquisition would be enhanced in multimodal conditions. Each of the four groups (visual-visual, visual-visual/kinesthetic, visual/kinesthetic-visual and visual/kinesthetic-visual/kinesthetic) had significant quadratic trends (see Table 3). The presence of the quadratic trend indicates that there is a distinct cut-off in ratings between new and old stimuli in all four of the conditions evaluated. Because the visual-visual unimodal group data exhibited a quadratic trend, it would be premature to conclude that specific exemplar information is enhanced through multimodal presentation. Although linear trends, not quadratic trends, have typically been reported in unimodal studies, it does not mean that quadratic trends were not present in the data. If quadratic trends are prevalent in the data of unimodal studies, then trend analysis may not be an adequate test to determine if multimodal stimulus presentation enhances the transfer of specific exemplar information.

The results of the present experiment contrasting unimodal and multimodal prototype formation are inconclusive. Although it appears that in some instances

Quadratic Model	
Group	F(1,82)
V-V	45.927***
V-V/K	55.335***
V/K-V	19.213***
V/K-V/K	29.833***

***=.001, **=.01, *=.05

Table 3. Quadratic Trend Analysis Results.

multimodally formed prototypes are somewhat more likely to be mistakenly categorized as old items than unimodally formed prototypes, it remains unclear whether or not the power of this tendency warrants the development of training programs emphasizing multimodal prototype formation. It is beyond the scope of this research to answer that question. Further research would be necessary to determine if such training may be of some benefit in a multimodal training domain where situational prototype formation can be examined.

Comparison to Solso and Raynis (1982)

Four of the nine conditions in the present experiment, the visual-visual, the visual-kinesthetic, the kinesthetic-kinesthetic, and the kinesthetic-visual, were a partial replication of a study by Solso and Raynis (1982) on the cross-modal transfer of unimodally formed/recognized prototypes. Although minimal, there are some differences between stimulus presentation in the present experiment and in the Solso and Raynis (1982) study. The present study had more subjects, used a visual stimulus presentation time that was five seconds longer, and used active, rather than passive, kinesthetic stimulus presentation. These differences did not have a dramatic effect on the replication. Stimulus number 17, which had been removed from the data set of the present experiment as a contaminated item, was included in all analyses comparing the present experiment with Solso and Raynis (1982). Upon visual inspection, symmetry of the data from the two experiments is apparent (see Figures 5 & 6). However, statistically the findings of Solso and Raynis (1982) were only partially replicated (see Table 4).

In both experiments, group analyses of variance revealed that some of the recognition stimuli were rated significantly different from one another in the visual-visual, kinesthetic-visual, and kinesthetic-kinesthetic groups (see Table 4). Solso and Raynis (1982) also found that the visual-kinesthetic group rated some of the recognition stimuli significantly different from one another, while the present experiment did not. These

Group	Anova	Linear Model	P vs. Old	P vs. New	New vs. Old
Present Experiment	F(7,88)	F (1,94)	t (11)	t (11)	t (11)
V-V	27.390***	27.518***	-4.36***	—	11.78***
V-K	—	7.422**	—	—	2.26*
K-V	2.641**	—	—	—	—
K-K	7.392***	26.396***	—	3.56**	5.55***
Solso & Raynis (1982)	F(7,63)	F (1,63)	t (63)	t (63)	t (63)
V-V	8.289***	29.902***	-2.38*	—	5.69**
V-K	6.865***	41.193***	—	2.98**	6.21**
K-V	7.211***	20.792***	—	2.92**	2.41*
K-K	6.531***	47.980***	—	4.34***	4.71***

***=.001, **=.01, *=.05

Table 4. Comparison of Present Experiment Replication Data with Solso & Raynis (1982).*

*Note that for the present experiment Student t values are reported while Solso & Raynis (1982) reported Fisher's LSD t values.

differences reported between the two studies will be addressed separately in the sections that follow.

Comparison of prototype ratings

Prototype ratings in the present experiment were equivalent to those of Solso and Raynis (1982) (see Figures 5 & 6). In both if the cross-modal groups in the two studies, the visual-kinesthetic and kinesthetic-visual groups, there were group tendencies to rate the prototype as an old item. The intra-modal groups in the two studies on the other hand, tended to rate the prototype differently from each other. The intra-modal kinesthetic-kinesthetic groups of both studies tended to rate the prototype as old, just as the cross-modal subjects did. Both intra-modal visual-visual groups however, exhibited group tendencies to correctly identify the prototype as a new item.

Comparison of stimulus ratings

T-tests were performed to examine the differences in subject ratings of new items, old items, and the prototype (see Table 4). The results of the t-tests for the present experiment are compared to those of Solso and Raynis in the following paragraphs.

Prototype Versus Old Items.

The findings of the t-tests comparing the prototype ratings to old item ratings in the present experiment were identical to those of Solso and Raynis (1982) (see Table 4). Subjects in the visual-visual groups rated the prototype and old items significantly different from one another. They were able to accurately classify the prototype as a new item and the old items as old items. The other groups could not accurately discriminate the prototype from the old items. Therefore, they did not rate the prototype significantly different from the old items.

Prototype Versus New Items.

The results of t-tests contrasting the prototype with new items in the present study only partially replicated the findings of Solso and Raynis (1982). The t-tests of the

kinesthetic-kinesthetic and visual-visual intramodal groups were replicated (see Table 4). In both studies kinesthetic-kinesthetic group subjects rated the prototype significantly different from new items and the visual-visual group did not rate the prototype significantly different from new items. Where Solso and Raynis (1982) found significance in the two cross-modal group t-tests contrasting the prototype with new items, the present experiment found non-significance. Solso and Raynis (1982) found significant differences between the prototype and new items in the visual-kinesthetic group $t(63) = 2.98$, $p < .01$ and the kinesthetic-visual group $t(63) = 2.92$, $p < .01$. Subjects in the present experiment did not rate the prototype and new items significantly different from one another in these two conditions.

New Versus Old Items.

The findings of the t-tests from the present experiment comparing the new items with the old items were identical to the findings of Solso and Raynis (1982) for all groups except the kinesthetic-visual group. Subjects in all the other groups rated the new and old items significantly different from one another (see Table 4). They were able to accurately discriminate between new and old items. In the present experiment, subjects in the kinesthetic-visual group did not rate the new and old items as significantly different from one another. In Solso and Raynis (1982) the subjects did rate these items significantly different from one another $t(63) = 2.41$, $p < .05$.

The graded ratings of stimuli relative to the prototype

For the linear trend analysis conducted across all stimuli that is presented in Table 4, the stimuli were ordered from 11, the prototype, through 18, the new item least similar to the prototype. The ordering of the stimuli for the trend analysis reflects the graded similarity of the old and new stimuli to the prototype. The present experiment replicated the significant linear trends Solso and Raynis (1982) reported for the visual-visual, visual-kinesthetic and kinesthetic-kinesthetic groups. These significant linear trends do not

conclusively determine that stimuli were rated more positively the closer they were in form to the prototype. These trends could be due solely to the difference between the prototype, old, and new items with no distance effect at all. The kinesthetic-visual group did not show a significant linear trend in the present experiment as it did in Solso and Raynis (1982) (see Table 4).

Differences between present experiment and Solso and Raynis (1982)

The exceptions in the similarity of the two studies consisted of one group analysis of variance, one group linear trend analysis, and three within group t-tests. To summarize, these differences were reflected in the analysis of variance for the visual-kinesthetic group, which was significant in the Solso and Raynis study (1982), but not significant in the present study. The linear trend analysis conducted across all stimuli for the kinesthetic-visual group data was not significant in Solso and Raynis (1982), but was significant in the present experiment. Furthermore, in three t-tests Solso and Raynis (1982) found significant differences where the present experiment did not; the three were the prototype versus new items in the visual-kinesthetic group, the prototype versus new items in the kinesthetic-visual group and the old items versus new items in the kinesthetic-visual group.

All the differences in the two studies reported above involve the cross-modal transfer groups that received either kinesthetic acquisition or recognition. As previously mentioned, the present study used active kinesthetic stimulus presentation, while Solso and Raynis (1982) used passive; this difference in presentation may be the cause of the differences in the results. Previous research (Held & Hein, 1963) has shown active acquisition to be superior to passive acquisition. In the present experiment people performed more accurately in active acquisition/recognition for comparisons of the prototype with new items than Solso and Raynis's subjects did in 1982 receiving passive acquisition. Cross modal subjects in the replication conditions of the present experiment did not rate the prototype significantly different from the new items. The prototype is a

new item. Active interaction with the stimuli in the present experiment may have given subjects a more efficient method to acquire specific exemplar information. Solso and Raynis's (1982) subjects did however, perform more accurately than subjects in the present experiment in passive acquisition/recognition for the comparison of the old with new items. In the present experiment the kinesthetic-visual group did not rate the old and new items significantly different from each other.

The unimodal data from the present experiment provides a good fit to the previous findings of Solso and Raynis (1982). The present study successfully replicated the findings of Solso and Raynis (1982) in most comparisons. The main differences between the two studies overwhelmingly point to the active nature of stimulus presentation in the present experiment.

Conclusion

The key finding of the present experiment is that strong prototype formation seems to occur in circumstances in which less specific exemplar information is transferred and weak prototype formation seems to occur under circumstances where more specific exemplar information is transferred. The kinesthetic acquisition groups formed the strongest prototypes of all the conditions and provide the greatest evidence for prototype formation. They also were least accurate in their ratings of old and new items.

The attempt to determine whether a greater amount of specific exemplar information is transferred multimodally than unimodally was inconclusive. Two findings are relevant to this issue. First, although significant quadratic trends found in the present experiment indicate that a substantial amount of specific exemplar information is transferred multimodally, a significant quadratic trend was also found for the unimodal visual-visual group. Because the unimodal visual-visual group exhibited a significant quadratic trend it would be premature to conclude that specific exemplar information is enhanced through multimodal presentation. Second, there was some evidence to indicate that independent of

the unimodal or multimodal nature of stimulus presentation intramodal transfer is more accurate. In instances where differences in accuracy were exhibited by the visual and visual/kinesthetic groups the increase in accuracy tended to show up in the intramodal transfer groups regardless of the unimodal or multimodal nature of the stimulus presentation.

Results of the present experiment contrasting unimodal and multimodal prototype formation were also inconclusive. In analyses involving the visual and visual/kinesthetic only groups, the findings indicated that in some instances, multimodally formed prototypes are somewhat more likely to be mistakenly categorized as old items than unimodally formed prototypes. It should be noted however, that the strongest prototype formation occurred in the unimodal kinesthetic acquisition groups. There was also marginal evidence indicating that the multimodal formation of prototypes may be unique in that it allows for concurrent prototype formation and retention of specific exemplar information. Although unlikely, if this were true it would mean that individuals could form strong prototypes and at the same time have access to the specific information from which the prototype was built; this would be somewhat in opposition to the key finding of the present experiment stated at the beginning of this section.

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Appendix A

APPROVED BY THE MASTER'S THESIS COMMITTEE

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Robert Shively M.A., Research Psychologist,
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Robert Cooper Ph.D., Professor of Psychology, SJSU

APPROVED BY THE DESIGN AND ANALYSIS COMMITTEE

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May 10, 1991

TO: Donna Davilla, MA candidate

FROM: Kevin Jordan, MA Coordinator

RE: Design and analysis review

Drs. Hawkins and Wise have read your proposal for the Design and Analysis Committee. Their comments are enclosed. Based on the reviewers' comments and your response to Dr. Hawkins' comments, the proposal is approved.

Based on this committee's approval, the collection of data for your thesis is approved contingent on documentation of compliance with university policy regarding the use of human subjects in research. University policy requires approval of your project by the Human Subjects Institutional Review Board. Please provide me with a file copy documenting such approval as soon as you receive it. After that copy is part of your file, you may begin collecting data. [Note: received 5-2-91]

Congratulations on your progress to date! We look forward to the continuation of your fine performance in the program.

cc:

Cooper
Hawkins
Jordan
Shively
Wise
file

Office of the Academic Vice President • Associate Academic Vice President • Graduate Studies and Research
One Washington Square • San Jose, California 95192-0023 • 408/924-2480

To: Donna M. Davilla, Psychology
37316 Niles Blvd.
Fremont, CA 94536

From: Charles R. Bolz
Office of Graduate Studies and Research

Date: April 30, 1991

(Charles R. Bolz)

The Human Subjects Institutional Review Board has approved your request to use human subjects in the study entitled:

"The Transfer of Multimodal vs. Unimodal
Prototypes"

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the anonymity of the subjects' identity when they participate in your research project, and with regard to any and all data that may be collected from the subjects. The Board's approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Dr. Serena Stanford immediately. Injury includes but is not limited to bodily harm, psychological trauma and release of potentially damaging personal information.

Please also be advised that each subject needs to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate or withdrawal will not affect any services the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact Dr. Stanford or me at (408) 924-2480.

cc: Kevin Jordan, Ph.D.