Bayesian Modeling of Manner and Path Psychological Data

by

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Submitted to the Department of Electrical Engineering and Computer Science
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Abstract

How people and computers can learn the meaning of words has long been a key question for both AI and cognitive science. It is hypothesized that a person acquires a bias to favor the characteristics of their native language, in order to aid word learning. Other hypothesized aids are syntactic bootstrapping, in which the learner assumes that the meaning of a novel word is similar to that of other words used in a similar syntax, and its complement, semantic bootstrapping, in which the learner assumes that the syntax of a novel word is similar to that of other words used in similar situations. How these components work together is key to understanding word learning. Using cognitive psychology and computer science as a platform, this thesis attempts to tackle these questions using the classic example of manner and path verb bias. A series of cognitive psychology experiments was designed to gather information on this bias. Considerable flexibility of the subject's bias was demonstrated during these experiments. Another separate series of experiments was conducted using different syntactic frames for the novel verbs to address the question of bootstrapping. The resulting information was used to design a Bayesian model which successfully predicts the human behavior in the psychological experiments that were conducted. Dynamic parameters were required to account for subjects revising their expected manner and path verb distributions during the course of an experiment. Bayesian model parameters that were optimized for rich syntactic frame data performed equally well in predicting poor syntactic frame data.

Thesis Supervisor: Robert C. Berwick
Title: Professor of Computer Science and Engineering, and Computational Linguistics

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For more information, or a copy of the program used to conduct this experiment or the video corpus, please contact the author.

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Chapter 1

Introduction

How people and computers can learn the meaning of words has long been a key question for both AI and cognitive science. Creating computer programs that can converse with us as well as creating a more effective means of education are two examples of important advances which hinge on such understanding. Learning the meaning of new verbs has always been a problem for new learning theories. Verbs are characteristically harder to learn than nouns[12, 34] and their acquisition is relatively less studied, however some theories have been developed on generalized word learning.

It is hypothesized that people acquire a bias to favor the characteristics of their native language, in order to aid word learning. Other hypothesized aids are syntactic bootstrapping, in which the learner assumes that the meaning of a novel word is similar to that of other words used in a similar syntax, and its complement, semantic bootstrapping, in which the learner assumes that the syntax of a novel word is similar to that of other words used in similar situations. How these components work together is one of the keys to understand word learning.

In English, there is a small class of verbs of directed motion which describe the relative path of an action. Such verbs are often termed path verbs, and appear relatively infrequently in the English language. In fact, English is primarily a manner-based language: typically its verbs capture the manner of the activity (such as walk, run and jump). In many other languages, path verbs play a significant role in everyday speech [42], although in English manner verbs significantly outnumber path verbs.

As noted by Talmy, the relative rarity of path verbs in English leads most English speakers to think of these verbs as secondary. Like most linguistic biases we are not born with such a bias. This bias is important to understanding human word learning. How entrenched is this bias, and can it be reversed? What type of computer model can be developed to model this bias and its change over time in response to input? These are the questions that this research intends to explore.

1.1 Goals

This thesis has two major goals. The first is to investigate biases in the acquisition of manner and path verbs by conducting a set of comprehensive psychological experiments with child and adult subjects; the second goal is to develop a computer learning model that responds in a manner that is consistent with these experiments.

The psychological component contains several sub-experiments, two of which are fully presented here. The remainders are still in progress and are described in Section 4.4. The experiments present a series of single ambiguous examples of novel verbs and assess how subjects use information from their native language, as well as the training information presented during the experiment, to determine the meaning and important components of the novel verbs. During the course of an experiment, changes in the manner-path bias of the subjects are assessed and recorded. We hope to determine significant trends in the changes to the subjects' biases. Also, we hope to show the interaction between the bias and syntactic and semantic bootstrapping.

The results of these experiments are then used in the development of a computer model that simulates the human responses during the experiments. Starting with the initial bias of the subjects as derived during the experiments, the computer model progresses through the training and evaluation steps of the experiment in the same manner as the subjects. Model parameters are determined to provide the closest match between the model and human responses. The model is based on a Bayesian framework, and includes some unique additions that account for the human behavior observed during the experiments.

1.2 Applications

This work provides a detailed computer model that simulates how manner and path verbs are learned, and how the initial bias that influences this learning can be changed. The tools and techniques created to conduct the experiment will be of continued use, and the data will be useful for other analyses.

In addition to these implications, there are two main areas that may benefit from this research: early childhood learning and second language education. Shedding light on how children learn words from a small number of examples [20] could provide educators with important insights on which educational method more effectively takes advantage of the structure of the learning mechanisms identified by this work. Such insights would lower the likelihood of other prominent hypotheses of word meaning as well as to eliminate the noise inherent in such learning. One could extend the lessons of this work to reading because reading also involves visualization of actions or scenes.

When we learn a second language, we often have the most difficulty with the aspects of that language which conflict with the biases derived form our native language. To become fluent in a new language, these biases must be overcome. This research provides a focus on manner-path verb bias, and provides new understanding of the process by which manner-path verb biases can be changed. The insight that has been developed can be used to more effectively overcome such biases when learning a new language. This insight can be used to define the type of examples and style of learning which most effectively facilitates a language learner to acquire flexibility in handling language biases.

1.3 Guide to Thesis

This thesis is organized as follows. Section 2 discusses the relevant background in both psychology and computer science. Next, in Section 3, the software that was developed to conduct these experiments is described. A detailed discussion of the

pilot and final experiments and results is presented in Section 4. The development of a Bayesian model is described in Section 5, including an analysis of model predictions as compared to the experiment. Finally, Section 6 discusses the implications of this work.

Chapter 2

Background

2.1 Cognitive Psychology Background

The observation that a single presentation of a novel word and scene pair does not provide enough information for word learning [27], has been extensively demonstrated [13, 35, 1]. However, it has also been shown that both children and adults, when encountering a new word for the first time, will assign this word a meaning [6]. Although verb learning appears to be more difficult than noun learning, and often requires more exposures for learning to occur [34], it does appear that novel verbs can be learned after exposure to just a few examples. While there are many similarities in how people with different languages learn words, there are also systematic differences [41, 5, 7]. Native languages influence the learning of novel words, and influence the patterns of word extension. Both children and adults appear to be biased to learn word meanings in accordance with dimensions inherent in their language [17, 46, 44], and appear to use input information associated with their native language in developing these biases [11, 30, 38].

Tests such as these for cross-linguistic effects have been motivated by the Whorfian [45] hypothesis that language affects thought. In Whorf's view, differences between languages are reflected in differences in the way their speakers perceive the world. Indeed, research has shown that different languages require their speakers to notice different aspects of the world [36].

Cross-linguistic differences in word extension are more pronounced for verbs than for nouns [12]. Talmy [41] first started the work into what has become one of the more studied examples of cross-linguistic variation: the description of motion events. A motion event is made up of a moving person or thing (figure), the location relative to which it moves (ground), and the path that it moves along. Every language has a way of expressing these relations, but they differ based on the language. Manner-based languages such as English often pack the manner of motion into the verb, leaving the path information for optional prepositional phrases (*"He ran into the store"*). Examples of manner languages include English, Mandarin and Russian. Path-based languages, however, often encode the path into the verb and leave the manner to optional gerund (*"Él entró en la tienda corriendo"*). Examples of such languages include Spanish, Greek and Japanese. The following Spanish and English sentences are shown to further illustrate the differences between manner-based and path-based languages [28]:

1. Spanish: "La botella salió de la cueva."
   Translation: The bottle moved-out from the cave.
   English: "The bottle floated out of the cave."
2. Spanish: "La botella pasó por la piedra."
   Translation: The bottle moved-by past the rock.
   English: "The bottle floated past the rock."
3. Spanish: "La botella pasó por el tubo."
   Translation: The bottle moved-through through the pipe.
   English: "The bottle floated through the pipe."

In English, path verbs are relatively scarce [15, 41] and are contained within a single EVCA verb class [21]. Levin's book, *"English Verb Classes and Alternations: A Preliminary Investigation"* lists them as follows:

> (4.1) Verbs of inherently directed motion advance, arrive, ascend, climb, come, cross, descend, depart, enter, escape, exit, fall, flee, go, leave, plunge, recede, return, rise, tumble

The manner and path bias has been firmly established: it shows up in both distribution analyses and production studies with children and adults [2, 18, 4]. Because adults use features of their native language as a constraint in learning new words [24], this creates a bias towards interpreting a novel verb as having the features common to most verbs in one's language. It has therefore been speculated that this language-based bias is useful early in life, when one is learning many new verbs. Therefore the bias is fluid in childhood, and becomes more rigid and fixed as a person develops.

Related differences appear in other languages, across other dimensions. For example, an analogy can be drawn to the Korean concepts of "tight-fit" and "loose-fit". In English, putting a letter in an envelope or an apple in a bowl are similar concepts. Korean differentiates between an enclosing type of "in", such as putting a letter in an envelope, and a looser containment such as putting an apple in a bowl or glasses in a case. A study conducted by McDonough [22] included English and Korean speakers viewing a series of pictures of tight-fit and loose-fit situations. One of the pictures depicted was of a different situation than all the others. Korean speakers could identify the different picture; English speakers could not.

It seems apparent that the bias plays a large part in novel word learning. Given this, the goal in this series of experiments is to develop an understanding of a bias, and how it can be changed during the course of an experiment, as well as to assess bias differences associated with the native language of the subjects. We intend to demonstrate that the bias remains flexible over time, by inducing changes in the internal bias a subject has towards the dominant manner or path feature in their language.

It is suspected that this experiment would show that it is possible to shift an adult subject's bias during a single experimental session. This will be accomplished by asking subjects to learn a series of twelve novel nonce verbs with varying makeups of manner and path verbs. It is expected that during the course of the experiment exposure to a higher percentage of path verbs than are present in normal English speech will make the subject more willing to choose a path interpretation of the verb than a manner interpretation. Smith and Jones [37] were able to create a bias, with

17-month-old English-speaking children, to assuming a new object name refers to the object's shape, in a 9-month experiment. This conclusion was demonstrated outside the laboratory. Parents reported their children were more likely to assume a new word referred to an object's shape rather than its composition. Similarly, we suspect we can create a path bias in English speaking adults during an experiment session.

We also intend to investigate how syntactic frame plays a role in word learning. There are two different hypotheses on how syntactic frames interact with verb learning. In the syntactic bootstrapping theory introduced by Gleitman [13], language learners use the distribution of syntactic frames to help determine verb meaning. When a learner hears a new verb used within the same syntactic frame as a known verb, he assumes the two verbs are in the same verb class and take similar arguments. However, if the syntactic frame is different, the learner can infer that the novel verb is in a different class. Various experimenters have collected evidence in favor of this theory [23, 9]. Pinker [26], however, is in favor of the semantic bootstrapping hypothesis. This hypothesis stipulates that the learner uses common features of the scenes in which the verbs occur to determine verb class and arguments.

Inspired by this debate, we are also interested in the impact that syntactic frame has on the initial assumption that a verb is a manner or path verb based on a single scene and utterance pair. The syntactic frame *"He gorped up the stairs."* could be used for either manner (e.g. *"He walked up the stairs."*) or path (e.g. *"He ascended up the stairs"*), although it is more commonly used for manner. This frame is a richer syntactic frame: it provides additional information on relative motion of the sentence's subject. The frame *"He gorped the stairs"* is not used for manner verbs in English and is a content-poor frame.

Are subjects who are introduced to a verb with the rich frame more likely to choose manner than subjects with the poor frame, or are English speaking adults willing to acknowledge the existence of a possible new class of manner verbs that fit in that syntactic category? Other English non-manner, non-path verbs fit in a frame such as *"He punched the stairs."* Our first experiment used the rich frame syntax in presenting the utterance to the subjects.

We intend to show that syntactic frame will play a small role in the subject's final bias, but will be dominated by the semantic information. We will show subjects twelve scene and utterance pairs, made up of either entirely manner verbs or path verbs, and compare the bias measurement results to those in the first experiment, which uses entirely rich frames.

2.2 Artificial Intelligence Background

The second main goal of this project is to create a computer model that mimics the changes in subjects' path biases as they progress through the experiments. The concept of modeling verbs has been around since 1965 [32, 14, 8, 33]. Bayesian modeling is used in many different fields to model phenomena. In Cognitive Science and Artificial Intelligence, Bayesian modeling is used for everything from sensorimotor learning [19] to modeling of causal networks [40].

Much prior work [43] in modeling word learning did not account for the part syntax plays in learning. Other prior models utilized an extensive set of training observations [29], or were more complex than the phenomena we are studying [25]. We believe it is important that the model meet the following three requirements: extendibility, simplicity and realism.

First, the model should apply to all instances of this phenomenon without many changes to the actual model. Just as a human subject in the experiment does not know the test condition, and probably is not aware of the difference between such conditions, a single computer model must be able to accurately model human responses for each of the twenty different manner and path verb distribution conditions. If the model is to yield insights into human biases, the model must not be given knowledge that is not available to the subjects.

Secondly, the model should be simple. A manner and path verb bias seems like a rather simple mental structure in comparison to, for example, face recognition. A highly complicated mathematical model would likely be overfitting, causing the model to lose some of its generality.

Finally, the model must be realistic. The model must be consistent with current literature and thoughts in human learning, and should make common sense. We also would like the model to correspond well with the subject's behavior during the experiment and with their thoughts recorded on the exit questionnaire in the debriefing.

We will now turn to Bayesian modeling. Bayesian theory provides the basic structure for modeling a learner's current knowledge state, and how this state is altered based on new evidence. The posterior probability $p(H_i|X)$ of a particular hypothesis H_I being supported by some observed evidence, from within a learners total hypothesis space of H, is as follows:

$$p(H_i|X) = \frac{\prod_{j=1}^{N} p(x_j|H_i)p(H_i)}{p(x_1, ..., x_N)}$$

The term $p(H_i)$ is called the prior probability of H_i in the sense that it precedes exposure of the learner to new evidence X , which consists of the independent observations $x_1, .x_2$. The prior probabilities in conjunction with the hypothesis space comprise the prior state of a learner's knowledge. For a given H_i, the term $p(X|H_i)$ defines the probability of the evidence. The prior probabilities can be treated as dynamic, rather than static, to provide a mechanism for accommodating changes in a learner's biases. The observation that a person tends to use a particular variable in learning, which can be changed depending on language exposure, has been documented by Gentner & Boroditsky [12].

In this thesis we build upon this basic model to investigate distinct hypothesis spaces, priors, likelihoods, and posterior calculations in manner and path feature space for both computers and adults. The Bayesian modeling has three main aims. The first is to assess the model's performance in simulating a human subject's response to the different evidence sequences of each experiment condition. The second is to explore how changes to the basic Bayesian framework can model the thought process which subjects are experiencing while taking the experiment. The third is to explore what inferences can be drawn from the comparison for the first two to the actual experimental data.

Chapter 3

The Creation of Software - SmartPsych

This project included the development of flexible software that provides the capability to create online experiments. This system is convenient for both the Artificial Intelligence researcher and the psychology or cognitive science researcher, and supports use of the internet to provide an efficient experiment delivery and management system. The system can be used to simultaneously conduct experiments in different conditions from multiple computers within the same lab, help centralize a network of cooperating labs, or allow subjects to participate in experiments from home. These capabilities were important to this project because this research involved two universities, two labs, and many testing locations. The four major challenges in developing a software platform to fulfill this task are flexibility, ease of use, subject anonymity, and data storage and control. It is a CGI and command-line based system for Linux written entirely in Python.

3.1 Creating an Experiment

The system provides an interface that is used to create experiments. Two separate mechanisms for data entry are available: (1) an online GUI environment, and (2) a command-line program which reads a file formatted in a simple markup language. An

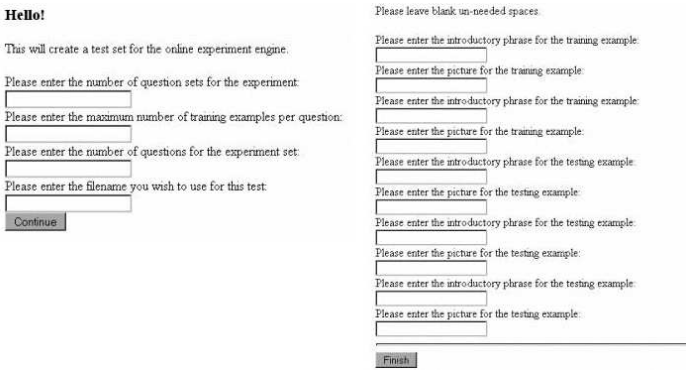

Figure 3-1: Screenshot from the experiment builder GUI

example of the GUI interface is shown in Figure 3.1, and the experimental scripts are provided in the appendix. These capabilities provide the flexibility to accommodate researchers with different needs for experiment size and control, i.e. the GUI provides for rapid development of short experiments, and the file reading program provides for development and control of large experimental projects.

The program is based on having a cycle of training and testing iterations, which is consistent with the form of most cognitive science experiments. Either component can be of any length (including 0), and the capability for variable iteration lengths is also provided. The prompt questions, for training and testing, can be customized. The entry program accommodates either a video or picture stimulus. All stimuli must be of the same type in the current version of the software, however, if warranted, this limitation could be eliminated in future revisions of the software. Overall, the system allows the experiment designer a relatively large amount of flexibility.

3.2 Running an Experiment

The process above creates a specially formatted .exp file that contains the experiment state. The file is loaded by one of two program templates: one for handling QuickTime

Figure 3-2: Screenshot from the resulting experiment.

videos and the other for handling pictures. These programs, in particular, were a challenge to write over the CGI interface. The program must keep track of its state while having to exit and reinstate itself each time the user submits a CGI frame, which happens whenever the user views a training or testing stimulus. The program accomplishes this using temporary files to which the program's state is marshaled or stored.

When the program ends, this same state variable is converted to an output file. There is one file for each subject in the experiment that contains an easy-to-read record of what radio buttons the user checked during the course of the experiment for each testing phase. It also includes additional information that will be useful in diagnosing errors within the CGI process or attempts of the subject to do things outside the bounds of the experiment. A screen capture taken during the pilot experiment which used this software can be seem in Figure 3-2.

3.3 Privacy and Security

Maintaining privacy is an important aspect of any psychological experiment. To incorporate this consideration into the software, it was necessary that a file and a subject could not be correlated. We employed a system that we had previously developed to fulfill this requirement. Upon initialization, each experiment object has a naming string such as `qmr` which identifies the name of the current experiment running. A random three-digit number is appended to this string to ensure that the experimenter did not know what order the subjects ran the tests. Because the pilot experiment used the method wherein subjects take the experiment over the internet, the experimenter does not know what time the subjects took the experiment. However, in a more controlled setting, where the time each subject takes the experiment could be determined, a more extreme method could be used to ensure anonymity. For example, randomly select up to four other files to copy to another file name. Somewhere within the copying of those four files, the program writes the subject's data. It will be impossible to tell if the subject who just finished testing was one of the rewritten files or the subject's actual file.

Chapter 4

A Psychological Experiment

The first step in this research was to design and test a pilot experiment aimed at addressing the issues and questions raised in the first half of this thesis. Once a design was defined, the actual conditions were completed as discussed below.

4.1 The Pilot

The pilot of the adult experiment design was tested to ensure that the selected experiment format was not confusing, as well as to determine if the format generated usable data. Several iterations of the pilot design were required to yield consistent results.

4.1.1 Methods

Subjects

Twenty subjects volunteered for the pilot of this study. They were graduate and undergraduate students, from the Massachusetts Institute of Technology, Carnegie Mellon University, Harvard University and the Rensselaer Polytechnic Institute. All subjects were unaware of the distinction between manner and path verbs, and were unaware of my work on this project other than its existence. English was the native language of all subjects tested in the experiment.

Stimuli

The stimuli in the experiment were samples from a small corpus of videos taken specifically for this experiment. Each video depicts a person performing an action which has salient manner and path components. Distracting elements were eliminated from the video.

In the pilot design we attempted to ensure balance. Subjects were tested with two different orderings in each of the manner and path cases. In the training videos we tried to alternate between our four actors, but always used the same actor for all videos within each individual phase. In the pilot we attempted to use non-human objects whenever possible, a practice which we eliminated in the final experiment design.

Procedure

In the pilot, each subject is presented with one sequence of questions that corresponds to one of the final experiments iterations, called blocks. Each iteration block is made up of four phases: (1)the initial stimulus, (2)the initial test phase, (3) the training phase and (4) final testing phase.

In the initial stimulus phase, the subject is advised that they will be asked to learn a new verb. The experimental software is then launched, either in person or over the Internet. Internet testing was only actively used in the experiment pilot although it remained an option throughout the future trials of the experiment. The screen presents the subject with the utterance "She's going to glip down the stairs". The subject then views a video depicting a person stoop-walking down a flight of stairs. By selecting **next**, the subject enters the initial test phase.

The initial test phase assesses the subjects current bias as to whether *glip*, the novel verb they had just learned in the first phase, is manner-based or path-based. This is accomplished by independently showing the subject two additional video clips: one capturing the manner aspect of stoop-walking, and the second capturing the path aspect of downward-motion. The subject must answer whether the action of either

of the clips involves the novel verb, *glip*. This selection provides an indication of the subject's current manner-path bias.

The third phase, the training phase, is different depending on whether the iteration block presents glip as a manner-based verb or as a path-based verb. In the pilot, half the trials were path-based training and half were manner-based training. Training consisted of presenting each subject with five training examples that show *glip* being used in the designated sense. The fourth phase is the final testing phase. The subject is again shown two videos: one depicting *glip* as a manner verb, and the other video depicting *glip* as a path verb. The procedure is the same as used in the initial test phase, except different videos are viewed. Subjects who have been trained on either manner or path verbs view the same videos in this phase.

Coding

An individual subjects results were coded by the computer and the final data was compiled by a human[1].

Results

The results of the experiment did not indicate any error in the experimental methods, and we decided to proceed with the experiment using this design. The results of the pilot experiment were not unexpected, matching our early theories and previous work on the problem.

It is clear that a vast majority of the subjects had a bias toward manner verbs, which was to be expected with English speakers. It could be speculated from the results that a few subjects seem to have acquired a more specific definition of, for example, "glipping", such that both manner and path were required for the subject to conclude that glipping was occurring. In the manner-based experiments, the data showed that almost all subjects initially perceived *glip* as a manner-based verb, and finished the iteration with the same perception. In the path-based experiments, a

[1]The term "coding" may be confusing to some readers. It is a conventional cognitive science and psychology term for recording the results of an individual subject in an experiment.

Pilot Results Path	**Pilot Results Manner**
Subjects tested: 10	Subjects tested: 10
Subjects with initial manner bias: 10	Subjects with initial manner bias: 8
Subjects with initial path bias: 0	Subjects with initial path bias: 0
Subjects with other initial bias: 0	Subjects with other initial bias: 2
Subjects who changed bias: 8	Subjects who changed bias: 2
Subjects perceiving glipping as manner: 2	Subjects perceiving glipping as manner: 10
Subjects perceiving glipping as path: 6	Subjects perceiving glipping as path: 0
Subjects perceiving glipping as both: 2	Subjects perceiving glipping as both: 0

Table 4.1: The preliminary results derived from the pilot experiment.

majority of the subjects changed their initial assessment that the novel verb was manner-based. These results are summarized in Table 4.1.

Since the pilot seemed to produce logical results and did not confuse subjects, a modified version of its design was adopted to create all the experiments in the set.

4.2 The Rich Frame Experiment

Prior work demonstrates that speakers of path languages and manner languages differ in their initial interpretations of novel motion verbs. This experiment explores the possibility that these biases are influenced by the set of verbs that a subject is exposed to and continue to be modifiable into adulthood. Each subject learned twelve new motion verbs. For each novel verb, subjects (1) saw a single ambiguous scene with a prominent path and manner of motion, (2) were tested to determine their initial interpretation of the verb (their bias), (3) saw five additional instances of the new verb which clarified the meaning (e.g. five scenes with same manner but different paths), and (4) were tested again to ensure that they had learned the novel verb.

An important part of this experiment was to vary the proportion of path and manner verbs across groups of subjects. Some subjects learned only manner verbs, some learned only path verbs, and others received different proportions of both types. It was predicted that the subjects would have little difficulty learning either the manner or the path verbs. The subject's manner-path bias was determined based on

the responses to the initial test trials, which immediately followed the first ambiguous scene. Because a single verb-scene pair is consistent with either a manner or path interpretation, responses to this test sequence reveal the subjects' biases. Because our subjects are English speakers, we expect that they will begin with an initial bias to interpret the novel verbs as manner-based. However, if the subject receives training that is different from their initial bias, then bias test results that differ from the initial results can be expected in response to new novel verbs. Consequently, it was predicted that over the course of the experiment, subjects who learn path verbs will develop a path bias, while those who learn manner verbs will retain the manner bias.

4.2.1 Methods

Subjects

Eighty-two adult native English speakers volunteered for participation in this study. Because the goal was to determine how previously learned verbs influence the interpretation of future verbs, we excluded all subjects who failed to learn five or more of the verbs after viewing the disambiguating scenes. Sixteen subjects were excluded for this reason.

Stimuli

Subjects saw short video clips of motion events. Each event depicted an actor moving in a prominent manner and path with respect to some reference object (e.g., a woman walking on tip-toes behind a large sign). Twelve manner and twelve path actions were selected.

The path verb meanings are: *around, out, between, down, up, in front of, along, in, diagonal to, over, across,* and *behind.* The manner verb meanings were: *crab-walk, crawl, twirl, flap-walk, hop on one foot, hop on two feet, march, run, skip, stoop-walk, tiptoe*, and *conventional walk.* Each manner verb was arbitrarily paired with a path verb.

The verbs that were paired had the same initial scene and the same test scenes.

Target Concept: Crab-Walk	Manner	Path
Ambiguous Scene	Crab-walk	Path
Initial Test: Manner	Crab-walk	Behind
Initial Test: Path	Skip	Out
Training One	Crab-walk	Front
Training Two	Crab-walk	In
Training Three	Crab-walk	Between
Training Four	Crab-walk	Across
Training Five	Crab-walk	Diagonal to
Final Test: Path	March	Out
Final Test: Manner	Crab-walk	Between

Table 4.2: Sample experimental block for a novel manner verb.

Target Concept: Out	Manner	Path
Ambiguous Scene	Crab-walk	Path
Initial Test: Manner	Crab-walk	Behind
Initial Test: Path	Skip	Out
Training One	Hop on 2 Feet	Out
Training Two	Walk	Out
Training Three	Run	Out
Training Four	Stoop-walk	Out
Training Five	Dance	Out
Final Test: Path	March	Out
Final Test: Manner	Crab-walk	Between

Table 4.3: Sample experimental block for a novel path verb.

For example, *crab-walking* was paired with path *out*. The initial ambiguous scene showed someone crab-walking out of a door. The first manner test item showed crab-walking under a bridge while the first path test item showed someone skipping out of a door. Pairing the items in this way allowed us to examine how subjects with different verb learning experiences responded to identical stimuli. The disambiguating videos were different for each member of a pair.

Subjects were presented with a block of questions and videos for each of twelve novel nonce verbs. Each block was identical in layout and was made up of four phases: the initial ambiguous stimuli phase, the initial test phase, the training phase and final test phase. An example test block for a manner verb is shown in Table 4.2 and an example for a path verb is shown in Table 4.3.

In the initial ambiguous stimuli phase of a block, the subject is introduced to a new nonce verb. The screen contains the video and a sentence explaining the scene (e.g. *"She is going to torg out the door."*). The subject then views a video of an actor crab-walking out a door. By selecting **next**, the subject enters the initial test phase, which tests the subjects current bias as to whether the verb they have just learned in the crab-walking initial stimulus phase is a manner or path verb. Each subject is shown two video clips: one capturing the manner aspect of crab-walking with a different path component, and the second capturing the path aspect of across-motion with a different manner component. The subject must answer whether the action in each of the clips involves the novel verb, *torg*.

The third phase, the training phase, is different depending on whether the subject is participating in a trial where *torg* is a manner-based or a path-based verb. Subjects are presented with five training examples showing *torg* being used as either a manner or path verb.

As in the initial test phase, in the final test phase two videos are sequentially displayed. One video has the manner aspect of the ambiguous scene and the other has the path aspect. Subjects who have been trained on either manner or path verbs view the same videos in the final phase test. Five conditions were run during this experiment. The conditions differed in the percentage of the twelve novel verb

blocks that were path-based actions. The conditions consisted of 0, 25, 50, 75 and 100 percent path verbs. The subjects were split evenly and randomly between all conditions. The twelve verb pairs were randomly ordered, and half of the subjects were tested with the blocks in reverse order.

Procedure

This experiment was run using the software described in Section 3. The subjects were told that they would be watching videos that would teach them new words, and answering questions about these words. Subjects then navigated through the computer program that presented them with the experiment blocks for the twelve novel verbs. They were then given a written exit questionnaire.

Coding

Subjects' responses were recorded by the computer during testing and entered into a spreadsheet. Path bias was calculated from the fraction of path verb questions to which the subject answered "yes", minus the fraction of manner verb questions to which the subject answered "yes".

Results

As previously noted and predicted, a definite manner bias for English speaking adults was confirmed. In conditions with a higher percentage of path verbs than English, it could be seen that subject's biases are changing to more path oriented. In the 100% manner condition, the subject's bias appeared to become more manner oriented. Subjects also learned faster than expected, often beginning to choose path-biased verbs within the first five blocks rather than at a point closer to the center of the experiment. Path bias was calculated as the difference between the number of path-based choices and the number of manner-based choices. Figure 4-1 depicts the path bias at the end of the experiment for each of the five conditions. There is a definite manner bias in the trials containing only manner-based stimuli, and a definite path bias in those containing path-based stimuli.

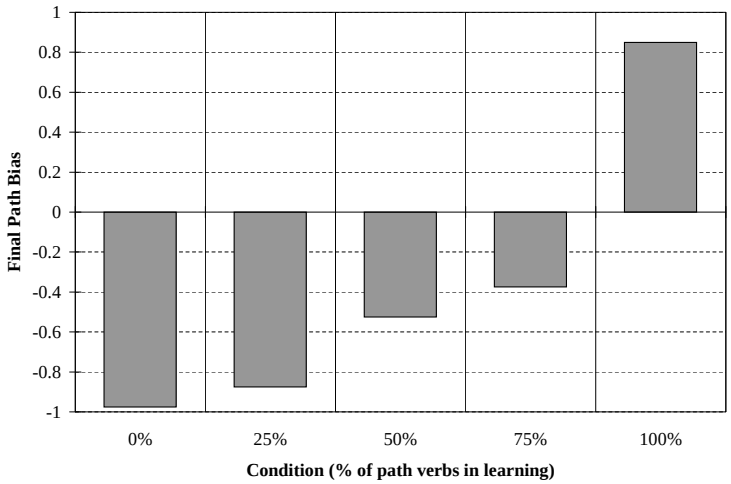

Figure 4-1: The final biases for the rich frame experiment for all five conditions

The change in the path bias between the first four verb blocks and the last four verb blocks was calculated, as shown in Figure 4-2. With the exception of the 75% path verb condition, the bias differences seem to follow an increasing pattern. The dip in the 75% condition could be due to the fact that subjects learn a path bias early, because it is apparent to them that a significant portion of the verbs already shown were of path in nature.

4.3 The Poor Frame Experiment

In the rich frame experiment, the sentences that were used contained a preposition as well as a ground element, an object that the motion seems to be relative to. In English, this type of frame is more frequently used with manner verbs, although it can be used with path verbs as well (e.g. *"She ran around the tree."* or *"She circled around the tree."*). In order to determine to what extent the effects witnessed in the rich frame experiment were in some way influenced by this syntactic frame, a simplified version of the experiment was conducted with a information-poor syntactic frame.

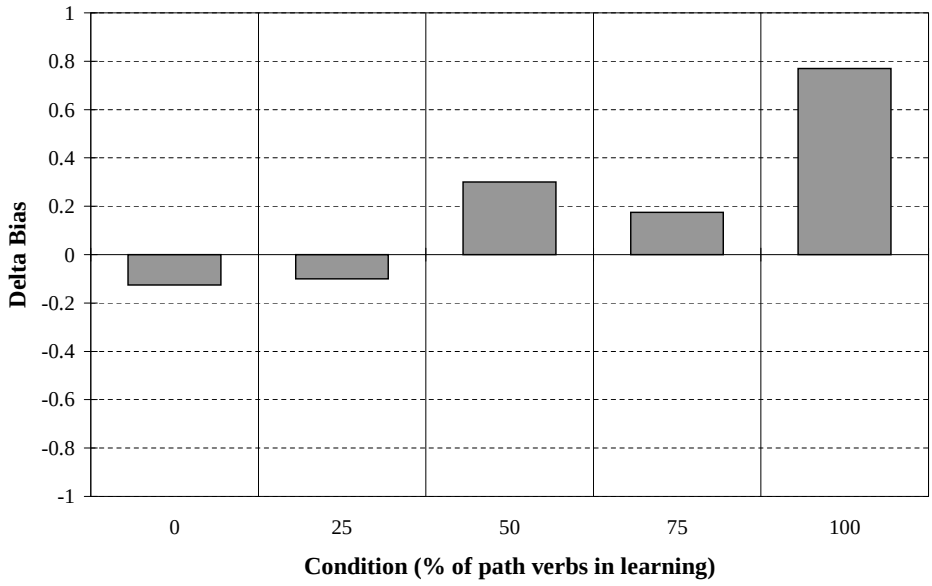

Figure 4-2: The change in biases for the rich frame experiment for all five conditions

This experiment replaces the syntactically rich frame sentence with a syntactically poor frame sentence without a preposition (e.g. *"He gorped down the ramp."* became *"He gorped the ramp."*). These poor frames are more commonly used with path verbs in the English language.

4.3.1 Methods

Subjects

Fifty-five Harvard and MIT students volunteered for participation in this study. They received course credit or were paid for their participation. The responses of 50 subjects were counted in the results. The subjects were all native English speakers. Responses

from five subjects were not included for the reasons previously noted.

Stimuli, Procedure and Coding

The procedure was identical to the rich frame experiment, except that subjects were presented with a semantically poor frame in the prompting sentence. For example, instead of *"He torged down the stairs."* the subject was presented with *"He torged the stairs."* This sentence is missing the information provided by the preposition *down*, and provides a better match with a syntactic frame used by English manner verbs.

Results

Consistent with the rich frame results, a definite manner bias was observed during the initial test phase of the poor frame experiment. The subjects were also much more likely to pick a path-based verb after viewing the 100% path training examples. Statistically, there is very little difference between using a rich frame and using a poor frame for either the 100% path-biased verbs or manner-biased verbs. See Figure 4-4 for an illustration of the final path bias for these conditions and Figure 4-5 shows the changes in bias for the poor frame experiment.

It is also interesting to note that the initial bias, measured in the first four blocks, is slightly lower for manner and slightly higher for path as can be seen in a comparison between the initial 0% and 100% values (Figure 4-6) and relatively the same for the final (Figure 4-7). This suggests that a known syntactic frame can itself be a bias that affects the learning of new verbs. Possibly it took subjects more time to accept the novel syntactic frame as a probable frame for a manner verb than the more familiar frames of the rich frame experiment. One can see a more pronounced version of this effect while comparing the final biases in the 50% and 75% path conditions (Figure 4-3). The final path bias is higher on the poor frame conditions showing that syntactic frame does play a role in a situation of uncertainty. The syntactic frame resembling the typical path verb frame made it easier for a learner to accept that a verb was a

path verb. This shows evidence of syntactic bootstrapping, while the ability to learn verbs out of their familiar syntactic frames indicated semantic bootstrapping. One can argue that a mix of both effects is at work here.

4.4 Experiments in Progress

To extend the results cross-linguistically and across age groups, we intend to continue after the completion of this thesis. Our ongoing experiments, as well as our expectations regarding results, will be discussed.

Next to be completed will be a rich frame and poor frame experiment tested on Spanish bilinguals. We currently have most of the data for the rich frame and it should be analysed shortly. We will test Spanish bilinguals in rich frame sentences using a translated version of the English speakers' rich frame experiment. A native Spanish speaker performed the translations. The experiment was conducted entirely in Spanish, with all documentation in the pre- and post-experimental stages also in Spanish. We predict that the Spanish speakers will be more path-based and will more easily accept a verb to be a path verb. However, Spanish is not an entirely path-based language and we predict that the rich syntactic frame will cause a more manner-biased set of results than a translation of the poor frame.

Additional experiments are planned with kindergarten age and younger children, initially conducted with English speakers and progressing to Spanish bilinguals. This study is in the prototyping stage. There has been an extensive amount of work directed at demonstrating and explaining how language affects children's early word learning, but this work has mainly focused on nouns and object labels [17, 46, 30, 38]. Because, as previously noted, cross-linguistic differences are more prominent for verbs (for a review see [12]), our planned studies will provide important insights into what impact cross-linguistic differences have on early verb learning. Further, according to Hohenstein[16], preschoolers may not yet have language specific biases, including manner and path, although input driven bias adjustments have been reported [31].

The pilot of the kindergarten age experiments includes some revisions in the experiment structure. There are only eight blocks with only six critical trials. Based on the lessons-learned from prior experiments with very young children [39], this shortened version should be beneficial in maintaining children's attention during the testing. We hypothesize that children at this young age will have weaker biases, and will be more amenable to both the concept of path verbs as well as to different syntactic frames. Currently in the experimental design stages is a study of very young children, directed at defining the age when this bias is first instantiated. This will require study of children prior to the development of biases from their native language.

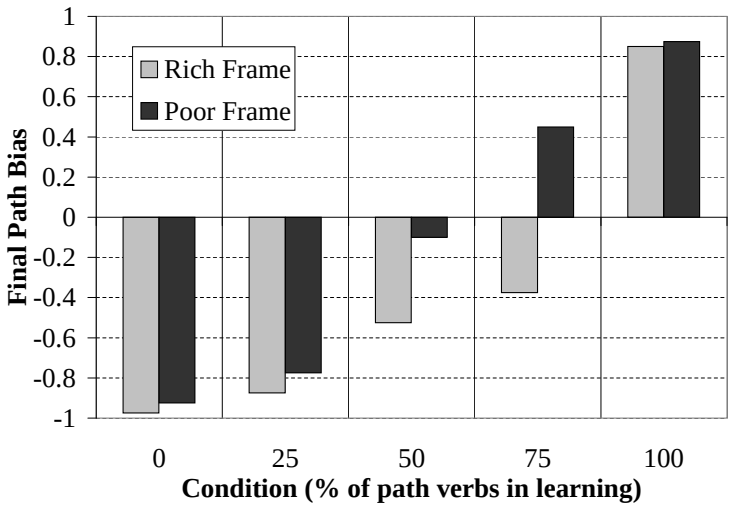

Figure 4-3: Comparison between the rich and poor frames for all conditions.

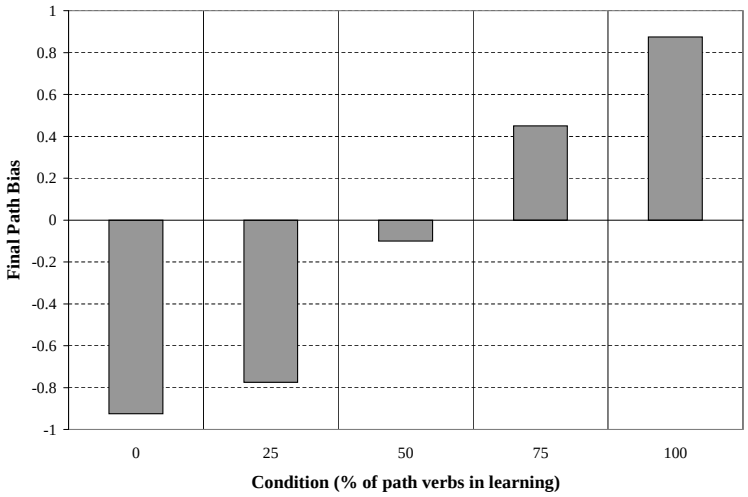

Figure 4-4: The final biases for the poor frame experiment for all five conditions.

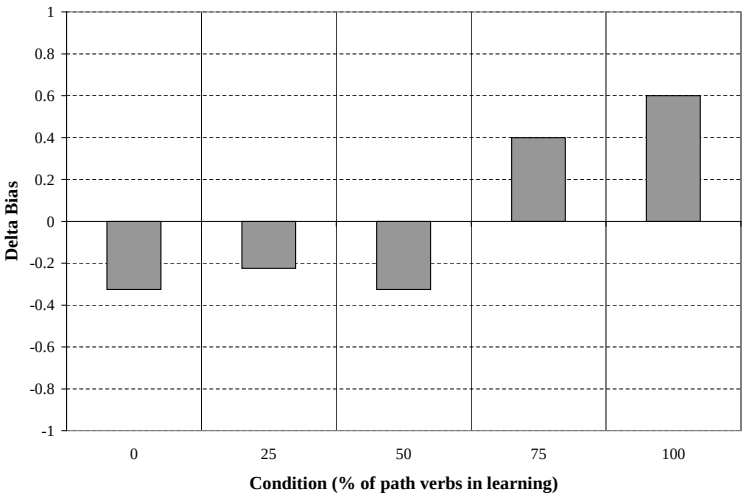

Figure 4-5: The delta biases for the poor frame experiment for all five conditions.

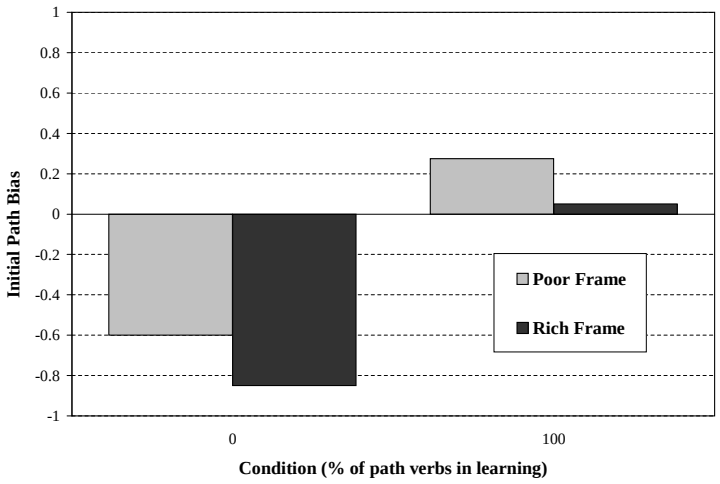

Figure 4-6: Comparison between initial path bias for 100% rich and poor frames conditions.

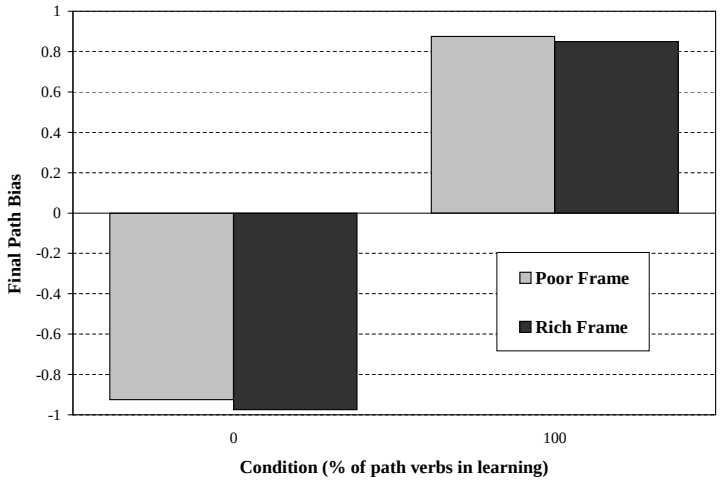

Figure 4-7: Comparison between final path bias for 100% rich and poor frames conditions.

Chapter 5

A Bayesian Model

In Section 2.2 we discussed our goals and plans for the Bayesian model. We listed three goals of the model to be extendibility, simplicity and realism. To fulfill these requirements, we propose to use a modified Bayesian model. In this chapter, we will first explain the basic principles behind Bayesian analysis. Next we will discuss a more specific but simplified application of Bayesian analysis to the problem at hand. We will then discuss modifications to the standard Bayesian model, which were adopted to account for idiosyncrasies that developed in the behavior of the model, as well as to better simulate the mental processes of the subjects.

Before describing the model, we note the practical issues associated with the visual parts of the human experiment. Because computer vision necessary for analysis of the experiment videos is unavailable, the main ideas in each video clip are encoded into short strings of text describing them, and are presented to the computer as such. This simplification, although not completely realistic, is necessary with today's artificial intelligence technology, so unfortunately this portion of the model must be abstracted. These considerations, as well as the other difficulties inherent in this project, pose a unique challenge in model design.

5.1 A Basic Model

In this section, we will describe how to apply a basic Bayesian model to the problem of modeling the acquisition of manner and path verbs. This task differs from prior research in several ways.

Firstly, we incorporate both syntactic and extra-syntactic evidence in the same model rather than just syntactic constraints alone. An example of a syntactic feature is the sentence frame that differs between the rich and poor frame experiments. An example of an extra-syntactic feature is the manner or path aspects of a video frame. Niyogi [25] has derived a complicated model to handle this general problem but we believe that a simpler approach is called for in modeling this bias which we will describe in this section. The second difference is in the input. We are considering joint scene-sentence pairs rather than just sentences or scenes. Thirdly, we incorporate dynamically changing prior probabilities into the model framework. The changes are influenced by past language exposure and the current experimental content. Finally, the model will be tested with the data from actual adult language learning experiments in manner-path bias.

As a first step in creating such a model, we must first identify the features we require in the model to support our goal of the computation of posterior probabilities from the scene-utterance pairs of the verb learning experiments. As noted previously, we unfortunately cannot take actual features from the video clip but must determine the important features and transcribe them for the computer. Further we need only to encode the differences between the trials because the model will only attempt to model changes within the different trials of one experiment. By fixing all input except the syntactic framework and semantic features of the novel verbs, we assume all other learner knowledge is perfect; that is, adjectives, nouns, word order, etc. have all been fixed. Changes between the experiments, such as language distributions and biases and syntactic information, can be encoded by changing the initial settings of the model.

To begin we look at both linguistic and extra-linguistic differences between the

various stimuli in the experiments. First we will discuss syntactic features and how we choose to represent these features. In the experiments, we changed between a "rich frame" and a "poor frame" as extensively discussed in the experimental section. We noted that this change produced a significant effect only in the initial blocks of the experiment. This indicates that the effect can be handled in the initial settings, which decrease in importance as the trial progresses. We have chosen to only include syntax in the original settings because they remain constant throughout the experiment. Alternately, we could have added another variable to the scene description, characterizing the syntax of the sentence, such as a variable encoding a person's location (i.e. behind or in front of) in the video or a variable encoding the color of the actors shirt. However this seems unnecessary because many such results can be combined effectively into one variable.

Turning now to extra-linguistic features, we note that the obvious extra-linguistic feature is the manner and path of the verb, which can be represented in two ways: one simple and one complex. The simple method is to label each stimulus as "manner", "path" or "neither" for the main classes of the subject's answers, as well as the hypotheses of the subjects and the main features of the clips. The more complex method involves labeling each clip with a distinct manner and path, and determining the degree of strength for each manner or path component. This more complex method could capture the confusion some subjects had about certain verbs. However, this capability was not considered necessary because subjects who where confused, as determined by their inability to learn more than three verbs after viewing five examples of each, were disqualified from the experiment. Subjects who were included in the study did not have difficulty learning the verbs, and were deriving a pure manner and path stimulus from the block. Therefore, we have chosen to represent each block with a label "manner", "path" or "neither". The events E_M, E_P and E_N represent the events that a manner, path or neither event was viewed.

This fixes the hypothesis space, H, to be the set of bias numbers for the three classes, "manner", "path" and "neither". Recall that in the experiments, the bias was calculated by subtracting the fraction of manner verb questions to which the subject

answers yes from the fraction of path verb questions to which the subject answers yes. Assuming these hypotheses, subjects who view scenes containing a novel verb, not knowing the value of its manner and path feature, must choose among three distinct hypotheses: H_M (manner), H_P (path), H_N (neither). Selecting H_N (neither) indicates a subject considers the verb to be more specific, or more general, than a manner or path verb. One scene cannot uniquely fix the value of this feature, so we look at the entire block as one stimulus unit.

To illustrate, we will now tie this discussion to both the experiment and the model decision made above. We will use the poor frame condition that was half path verbs and run in the forward direction as an example (`df50_50`, see appendix for information on specific conditions). In this test, subjects were shown an equal mix of manner and path verbs using the poor syntactic frame. We model the experiment X as a sequence of extra-syntactic block stimuli presented to the learner with X_i being the observation of a particular block. For example, in this experiment:

$$X = [E_P, E_M, E_M, E_P, E_M, E_M, E_P, E_M, E_M, E_P, E_P, E_P]$$

Then, if each of the three hypotheses are a priori equally likely and so encoding no information, the learners prior probabilities $P(H_i)$ are all $1/3$. However, we know this is not the case. We will calculate the priors from the actual results in the first question of each experiment using each syntactic frame, thus taking syntax into account. In this example, since it is the poor frame, we calculate the following priors:

$$H_{M,prior} = 0.56,\ H_{P,prior} = 0.17,\ H_{N,prior} = 0.27$$

Putting these together, we obtain the likelihoods for the learner to hold each hypothesis given the data that was just presented. These are expressed as $P(H_i|E_j)$, and will often be referred to simply as "likelihoods". The subject is much more likely to hold a manner hypothesis given a manner stimuli block, and a path hypothesis given a path stimuli block. The likelihoods are determined to make the model best fit the data; they are the free variable of this analysis. The likelihoods remain the

	H_M	H_P	H_N
E_M	0.72	0.06	0.22
E_P	0.06	0.72	0.22
E_N	0.22	0.22	0.56

Table 5.1: The likelihood values for the Bayesian model.

same for both syntactic frames:

The hypotheses and prior probabilities, together, define a learner's knowledge state. Given some sequence of scene observations X, in the form of an experiment, we can now directly compute the posterior probability of any of the three possible labels.

As the experiment progresses, each block observation further reduces ambiguity over the possible concepts. The final component of the static Bayesian model is the divisor, $P(E_i)$, which represents the probability of these events in the natural language tested. We will refer to this variable as the divisor throughout this section. The divisor is completely determined by the likelihoods and the priors, as shown below.

$$\begin{aligned} P(E_i) &= \sum_j P(E_i \cap H_j) \\ &= \sum_j P(E_i|H_j)P(H_j) \end{aligned}$$

Given the values above, we calculate the divisors[1]:

$$\begin{aligned} P(E_M) &= 0.56 \cdot 0.72 + 0.17 \cdot 0.06 + 0.27 \cdot 0.22 \approx 0.473 \\ P(E_P) &= 0.56 \cdot 0.06 + 0.17 \cdot 0.72 + 0.27 \cdot 0.22 \approx 0.215 \\ P(E_N) &= 0.56 \cdot 0.22 + 0.17 \cdot 0.22 + 0.27 \cdot 0.56 \approx 0.312 \end{aligned}$$

We put all these components together into Bayes' rule as follows:

[1]As expected, because exactly one of E_M, E_P, and E_N can occur in a given block (though the subject may be unsure of which), these probabilities add up to 1.

$$p(H_i|E_j) = \frac{P(E_j|H_i)P(H_i)}{P(E_j)}$$

Using the example so far, let us assume the subject has viewed a manner verb. We will now calculate $P(H_i|E_j)$, the probability of each hypothesis, given the observed evidence for the three hypotheses.

$$\begin{aligned}
P(H_M|E_M) &= \frac{P(E_M|H_M)P(H_M)}{P(E_M)} \\
&= \frac{(0.72)(0.56)}{0.473} \approx 0.852 \\
P(H_P|E_M) &= \frac{P(E_M|H_P)P(H_P)}{P(E_M)} \\
&= \frac{(0.06)(0.17)}{0.473} \approx 0.022 \\
P(H_N|E_M) &= \frac{P(E_M|H_N)P(H_N)}{P(E_M)} \\
&= \frac{(0.22)(0.27)}{0.473} \approx 0.126
\end{aligned}$$

5.2 A Dynamic Model

The simple Bayesian computational analysis described above considers static biases of generalization, modeled solely within the prior values $p(H_i)$. But Bayesian analysis also provides a commonly used framework for exploring changes in word learning biases. As the experiment progresses, the learner's prior bias changes with the correct and incorrect guesses they make and with the words they learn. In this set of models and experiments, we aim to model how the process of verb learning can shape priors. We can generalize the static prior case described above to the situation of changeable priors, thus modeling the change in bias that occurred during the experiments in Section 4.

Above, we have calculated values such as $P(H_M|E_M)$. Given that the subject has just seen an E_M event, this indicates that $P(H_M)$ should be updated to be the value we calculated for $P(H_M|E_M)$. In this way, we use the Bayesian probabilities to calculate the subject's changing bias.

5.3 Giving the Model Memory

The model we have described does not completely capture the behavior exhibited by subjects during the experiments. The learning curve exhibited by subjects is not smooth; rather, it has lots of abrupt changes. We speculate that subjects are considering all the blocks they have viewed during the experiment to set a new standard of "normal" for manner and path verb distributions. Essentially, they begin to realize that the "language" of novel verbs they are learning has a different distribution of verb types than English. For example, in the all path distribution, subjects reacted less to a new path verb based on the number of path verbs they had seen in the past. Also, the data indicated that a sudden change in input stimulus from a manner to path, and vice versa, had a dramatic effect on the immediate next response, which quickly subsided. We call this the memory effect.

If, due to the memory effect, the subject is changing his expectation of the frequencies of manner and path verbs, then in the model, the divisors $P(E_i)$ should be changing. However, these divisors are controlled by the likelihoods (which do not change) and by the priors, so the only way to change the divisors is to change the priors.

It is possible to recalculate the priors given the desired new values for the divisors, by applying Bayes' rule in reverse. However, the results are only consistent with the likelihoods for a small range of divisors. Anywhere outside that range, the formula yields probabilities that are less than 0 or greater than 1, indicating an inconsistency in the variable values.

When the values are consistent, they are fairly close to the values that were put in for divisors in the first place. So rather than updating the divisors, it is much easier to modify the prior values to weight them toward the desired divisor values.

As an example, if the subject has so far seen two manner events and six path events, he may conclude that path events occur about three times as frequently as manner events, at least within the scope of this experiment. We believe that his expectation of the probability of a path event ($P(E_P)$) will shift toward 75%, and

that this will be accomplished by shifting his probability of a path *hypothesis* ($P(H_P)$) toward 75%.

We now have two different effects changing the values of the priors. Bayes' rule is setting the values of the priors, and then we are weighting these values to take into account the memory effect. Thus we need to determine the weighting factor, which determines how much each effect plays a part in the final answer.

The power of the memory effect should increase as the experiment goes on. At the beginning, there have not been many experimental blocks, so the proportions of manner and path verbs in the experimental blocks seen so far should not have much influence. By the end of the experiment, though, the subjects' behavior seems to indicate that the memory effect has an effect comparable to that of Bayes' rule. We predict that if the experiment were to go on for many more blocks, the subject would be using the memory effect almost entirely, as they would be more certain that this language of novel verbs has a different distribution from English, and would be trying to determine what that distribution is.

We have modeled the memory effect by having its influence asymptotically increase over the course of the experiment. We set the weight of the Bayesian component to one at the beginning of the experiment, so the weight of the memory effect is zero. After each block, we multiply the weight of the Bayesian component by 0.95, increasing the weight of the memory effect correspondingly. This value of the parameter causes the weight of the Bayesian component to be 0.54 at the end of the experiment.

5.4 The Final Model

The techniques described in the previous sections result in a reasonably accurate model of the changes in human manner-path bias during the various experiments. For some conditions, the model "overreacts" to input, displaying a more extreme response than the human subject response. Also, the model accepts a path hypothesis more readily than the human subjects. In the path condition, the model as described so far quickly achieves a path bias of 100%, while humans are not nearly as certain.

Block	Bayes	Priors	Observations
1	0.95	0.04	0.01
2	0.90	0.07	0.02
3	0.86	0.10	0.05
4	0.81	0.11	0.07
5	0.77	0.12	0.10
6	0.74	0.13	0.13
7	0.70	0.14	0.16
8	0.66	0.14	0.19
9	0.63	0.15	0.22
10	0.60	0.15	0.25
11	0.57	0.15	0.28
12	0.54	0.15	0.31

Table 5.2: The changing weights of the Bayesian component and both components of the memory effect.

A possible cause of the problem is that the sample space for the memory effect is too small. Even after seeing three path verbs in the first three blocks, for example, a human subject will not conclude that 100% of the verbs are path verbs. Also due to the small sample space, a single manner or path event would change the proportions by an unrealistic amount.

We decided to account for this by initializing the values for the memory effect to be the priors at the beginning of the experiment. We gave these values the weight of 6 experimental blocks, so that it takes time to overcome them, but by the end of the experiment, the subject's observation of the events that have occurred in the experiment count for twice as much as the initial biases. The resulting weights of the Bayesian analysis, initial priors, and observations during the experiment are shown in Table 5.2.

Making this modification produced a small but noticeable change in the model's output. With this modification, the model's biases do not go to extreme values as often, and its behavior at the end of the experiment more closely matches the subjects' behavior.

Figure 5-1 compares the human subject data with three versions of the model: the model using only Bayesian analysis, the model using only the memory effect, and

the full model. For a more detailed look at this model, an easily readable version of the modeling code is presented in Appendix B, as `finalmodel.py`.

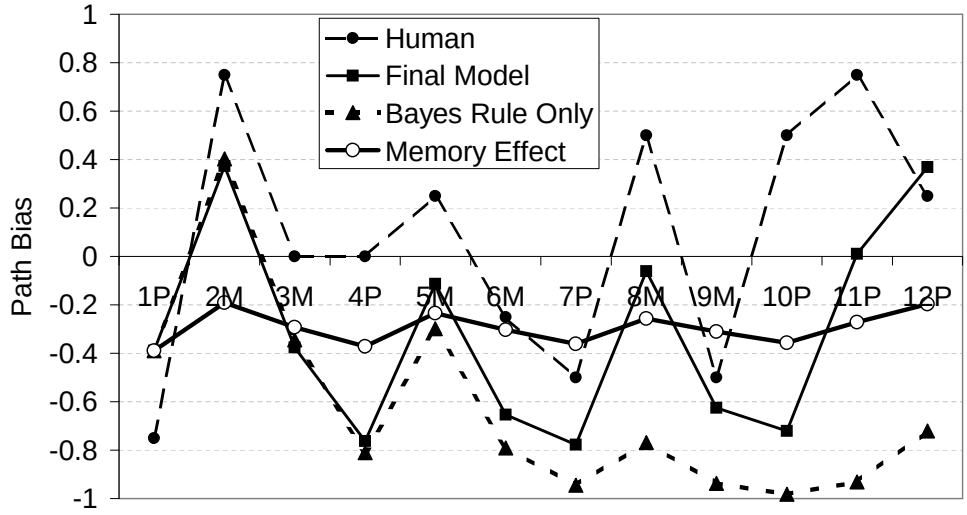

Figure 5-1: A comparison between subject data, a simple Bayesian model, the memory effect and our final model.

The model was developed to match the rich frame conditions. The same model also provided a good match to the poor frame experiment, having required only an adjustment to the initial priors to reflect the syntax change of the poor frame conditions. This is a demonstration of the universality of the model. Additionally, this is a realistic result that makes common sense. As previously discussed, the change in syntax caused a change in the initial values of the experiment, but became insignificant at the end. This result is paralleled in the model structure, as the initial priors and divisors become less important as the experiment progresses.

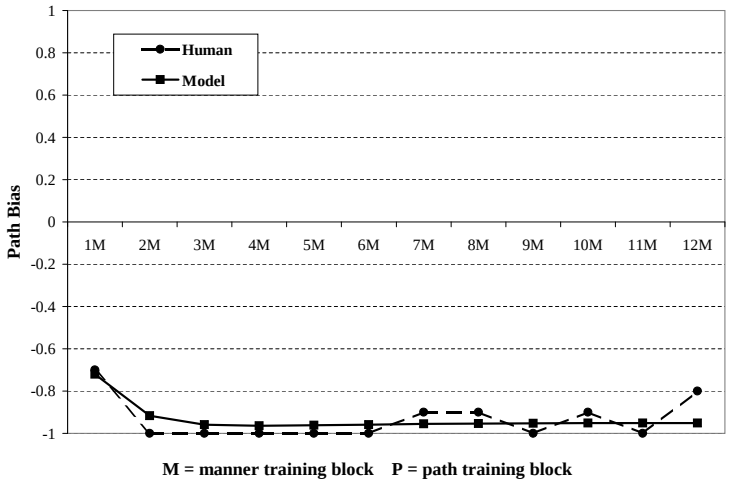

Figure 5-2: Comparison between the model and subjects on the rich frame 0% path condition.

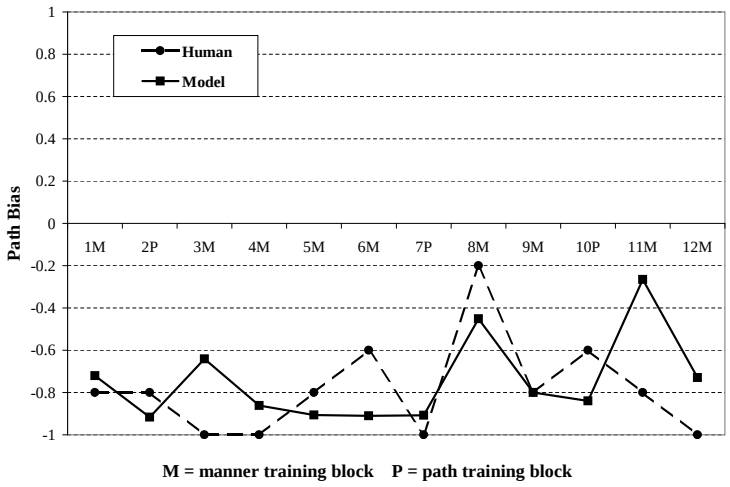

Figure 5-3: Comparison between the model and subjects on the rich frame 25% path condition run in the forward direction.

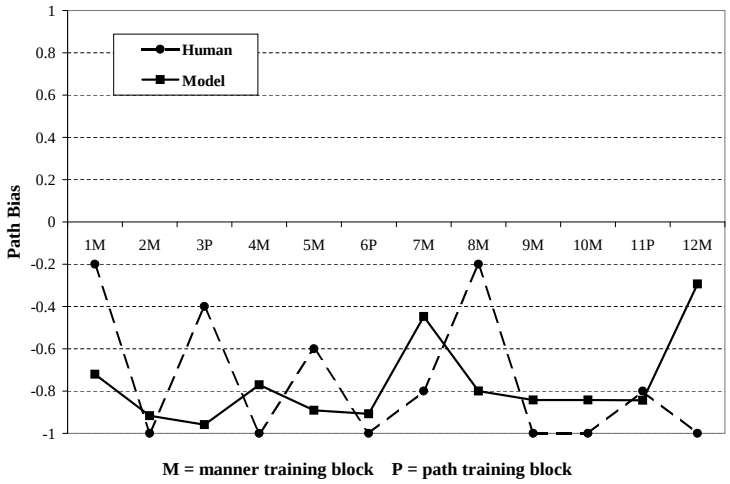

Figure 5-4: Comparison between the model and subjects on the rich frame 25% path condition run in the reverse direction.

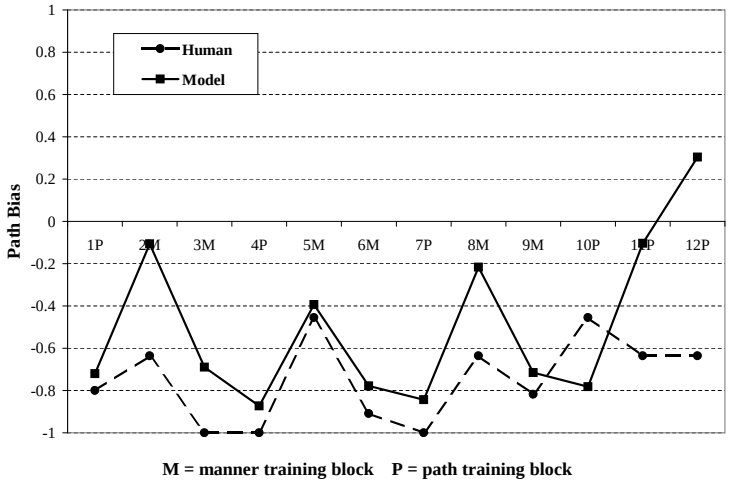

Figure 5-5: Comparison between the model and subjects on the rich frame 50% path condition run in the forward direction.

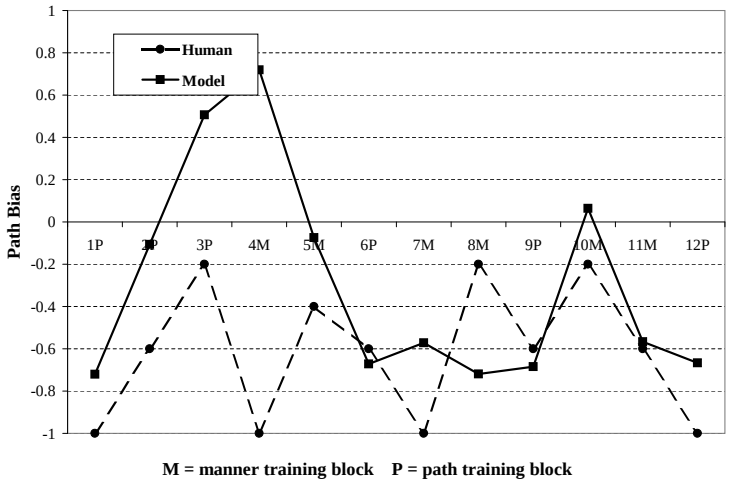

Figure 5-6: Comparison between the model and subjects on the rich frame 50% path condition run in the reverse direction.

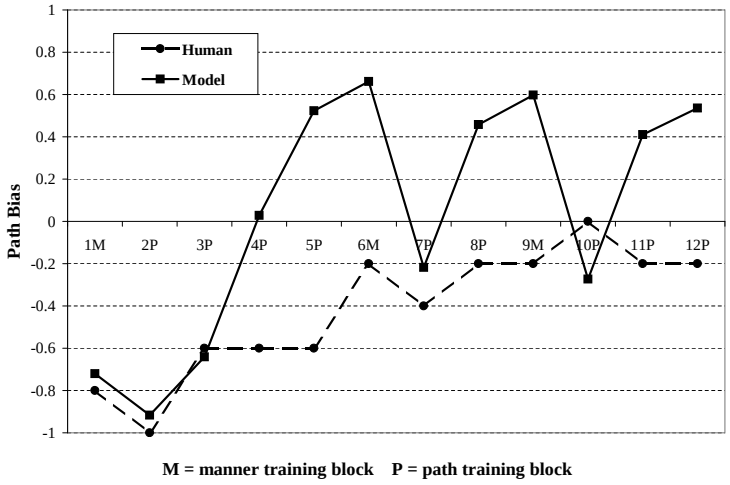

Figure 5-7: Comparison between the model and subjects on the rich frame 75% path condition run in the forward direction.

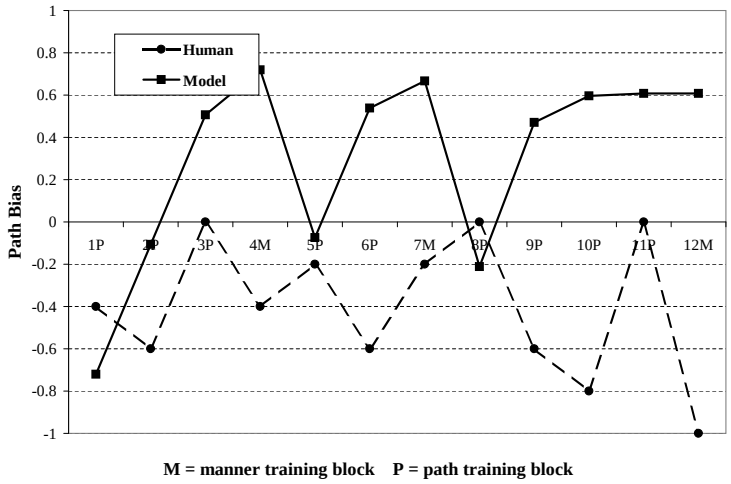

Figure 5-8: Comparison between the model and subjects on the rich frame 75% path condition run in the reverse direction.

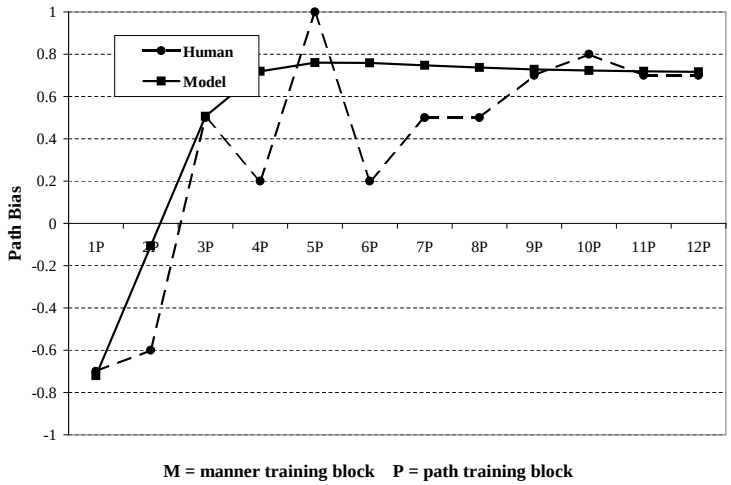

Figure 5-9: Comparison between the model and subjects on the rich frame 100% path condition.

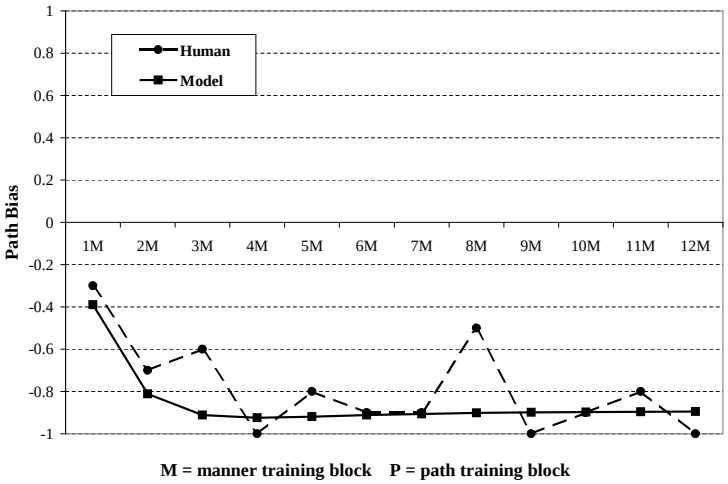

Figure 5-10: Comparison between the model and subjects on the poor frame 0% path condition.

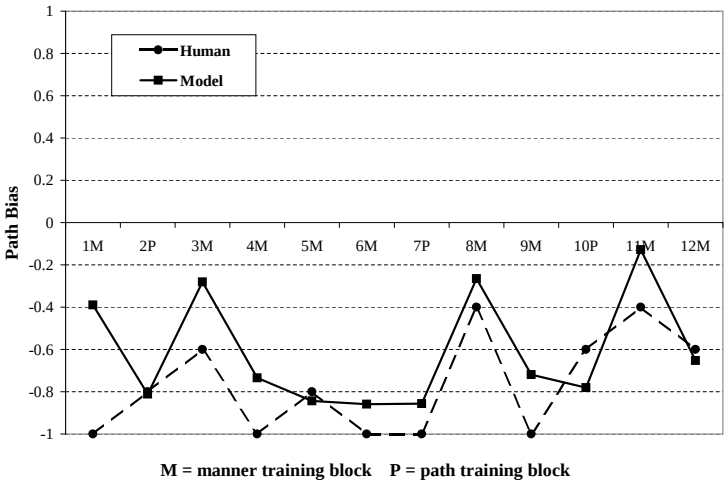

Figure 5-11: Comparison between the model and subjects on the poor frame 25% path condition run in the forward direction.

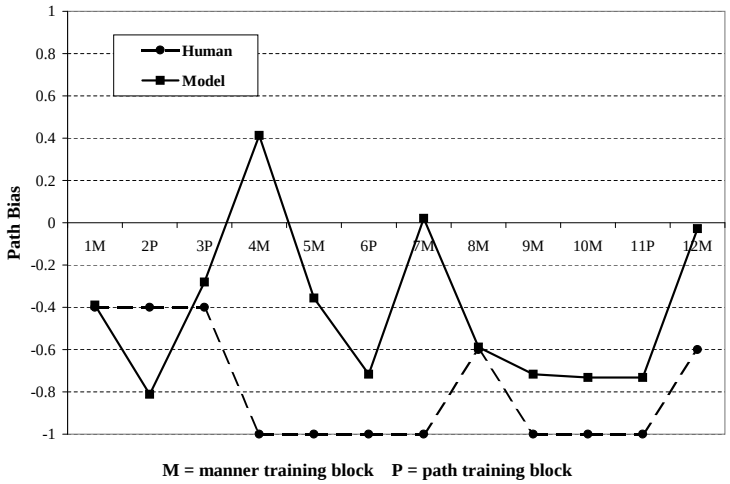

Figure 5-12: Comparison between the model and subjects on the poor frame 25% path condition run in the reverse direction.

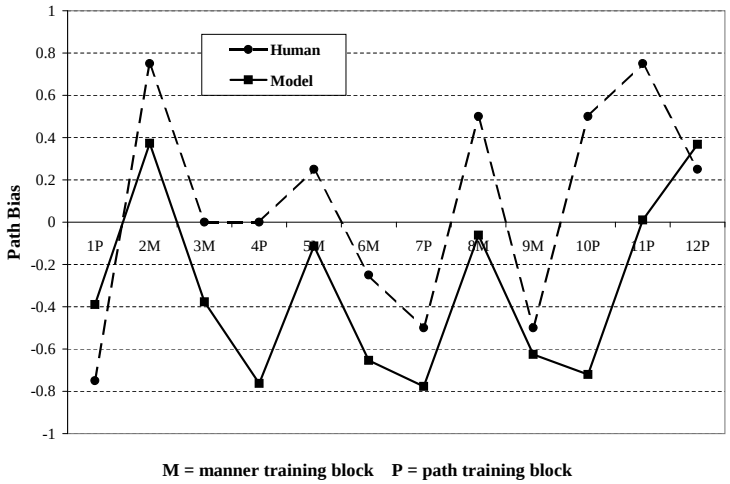

Figure 5-13: Comparison between the model and subjects on the poor frame 50% path condition run in the forward direction.

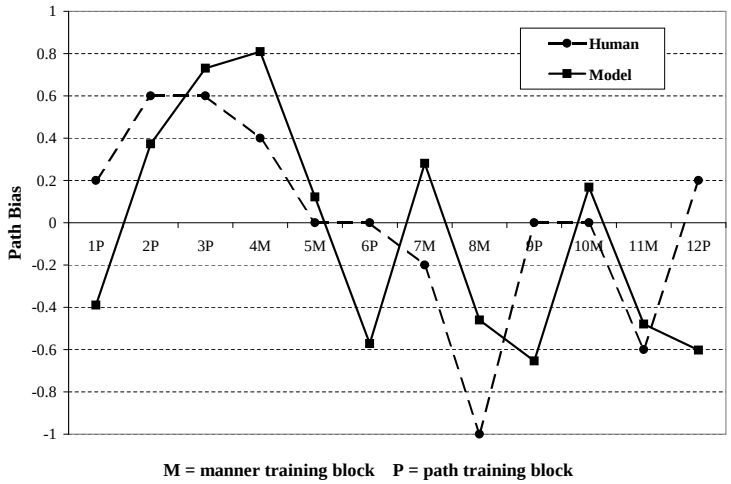

Figure 5-14: Comparison between the model and subjects on the poor frame 50% path condition run in the reverse direction.

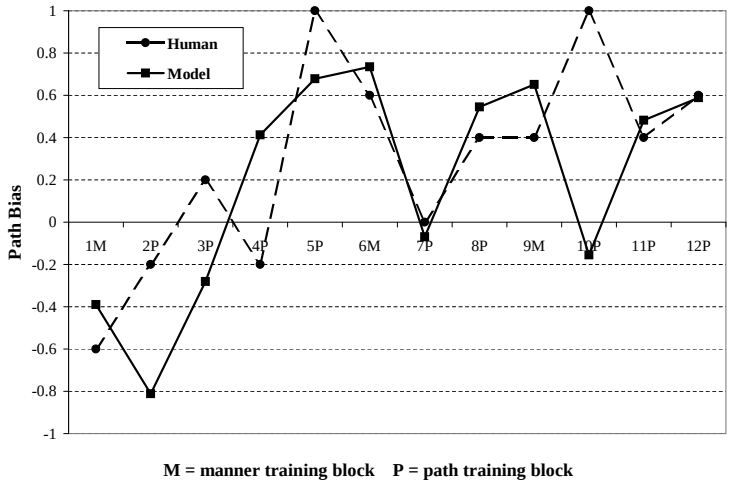

Figure 5-15: Comparison between the model and subjects on the poor frame 75% path condition run in the forward direction.

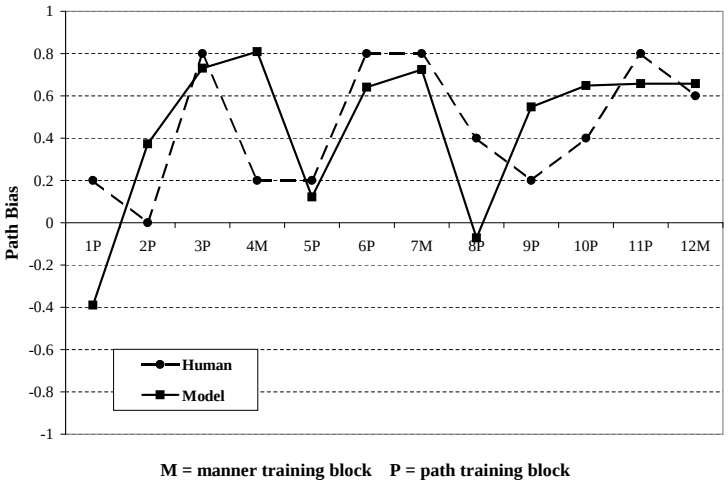

Figure 5-16: Comparison between the model and subjects on the poor frame 75% path condition run in the reverse direction.

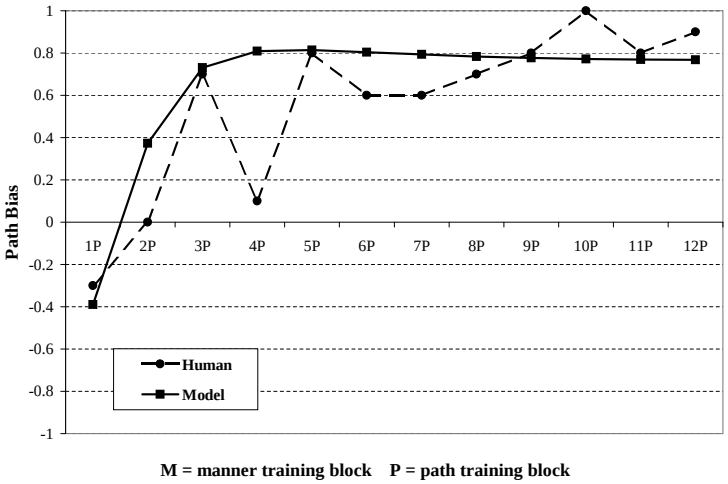

Figure 5-17: Comparison between the model and subjects on the poor frame 100% path condition.

We further assume that there could be a small error rate in the recovery of the information from the scene for the three different feature values, corresponding to any sort of perceptual or other noise. This noise accounts for the fact that a few subjects frequently choose the wrong verb meaning, after viewing five examples, and therefore their data was discounted. However, even a few of the subjects that remained qualified, especially in the quarter experiments, did not always perform rationally, and this hampered the modeling of this data. Figures 5-2 through 5-17 show the results of the model compared to the data.

5.5 Modeling For Child and Multilingual Experiments

The Spanish experiment is near completion, and the poor frame Spanish experiment will follow. We plan to change the model's initial priors for each of the different syntactic conditions, to reflect the Spanish learners prior knowledge relative to an English subject. Revision of the likelihoods is required to reflect that Spanish is a path based language.

Modeling adaptations will also be required for the kindergarten studies that will be initially conducted with English speakers, followed by Spanish bilinguals. The expected weaker manner bias, as compared to adults, will require changes in the initial priors and likelihoods to encode that young children have greater flexibility with respect to learning biases.

A potential future enhancement of the current experiments is conducting a randomized version, which would rule out noise and order effects. Modeling such an experiment would be an interesting challenge. One straighfoward possibility is to run all possible permutations of the input through the model. However, such an effort may be cost prohibitive. This is a problem with the current model because it is so determined with order effects.

Chapter 6

Conclusions

Previous research has shown that determining the meaning of words from single utterance and scene pairs is difficult [27, 13, 35, 1]; however, most people form an opinion on the meaning of a word from such a single scene [6]. This is especially true for verbs: verbs are more difficult to learn than nouns under many circumstances because verb learning usually requires more exposure to information than noun learning [34]. Irrespective of this, even preschoolers are able to form an opinion regarding the meaning of a verb after such a scene [3, 10].

These observations raise questions as to the mechanisms used for learning verbs so quickly. Naigles and Terraza [24] showed that there is a bias towards interpreting a novel verb as having the features common to the dominant verbs in one's native language. One now wonders as to the nature of this bias. How does it change with the surrounding language environment of the subjects? Does it remain flexible into adulthood? What point of exposure is sufficient to reverse the bias to the non-dominant form? Can such a bias, and how it changes with new information, be captured in a computer model? We chose to explore these questions using the manner or path verb features because it seems to be one of the clearer instances of a language-dependent feature.

These experiments demonstrate that biases in lexicalization patterns can be influenced by the words that a person learns. Native English speaking adult subjects were taught a selection of new verbs of a varying mix of manner and path. The path bias

of the subjects at the completion of the experiment was increased, consistent with the increase in the percent makeup of path verbs presented to the subject during the experiment.

At the completion of an experimental trial that employed path learning, most subjects displayed a bias for assigning an ambiguous scene and utterance pair as a verb with a path feature. These subjects began the trial with an initial manner bias, which was expected due to their native English language. In the course of the trial, their bias changed. All conditions with the subjects learning a higher percentage of path verbs than are present in the 75% manner condition resulted in the subjects being more willing to choose a path interpretation of the verb than a manner interpretation.

In designing this experiment, we had to choose between using a syntactically rich frame or a syntactically poor frame to describe the scene. We wondered what, if any, ramifications this choice would have on the results. How do adult subjects use the syntactic frame to determine the features of a novel verb, especially if a specific syntactic frame is more commonly used with a certain feature? In the second experiment, poor syntactic frames were used to teach sets of novel verbs that were either all manner or all path. Although initial biases were slightly more path-centric than the corresponding rich frame biases for the 100% manner or path conditions, the final manner and path bias for the weak and rich frames were very similar. However, in the ambiguous conditions of 75% path and 50% path, the subject in the poor frame conditions were more likely to choose a path meaning for a verb. This shows that a familiar syntactic frame makes a language learner more comfortable with a less-frequent interpretation of a verb.

There are three main insights and applications from this research in addition to those discussed above. First, this research gives insight into the mechanics of verb learning. Aforementioned researchers have supported the conclusion that adults have biases that are based on their own language. It is interesting that this bias remains flexible into adulthood. Although the bias is strong, it is easily overcome as the subject adjusts to the likelihood of the novel verbs.

A second interesting application of this work is to the Sapir-Whorf [45] hypothesis.

The weak Sapir-Whorf hypothesis states that the language we speak affects the way we think. Here the language we speak is affecting the way we perceive an ambiguous scene utterance pair. The features that we find more salient in the scene, and more likely to be encoded into a verb, are affected by the language we speak. If we speak a manner-based language, it is unlikely that a verb of directed motion could be what we are intended to take away from the scene. We notice the motion more prominently, and the direction of motion as a secondary thought. People who speak other languages may think the reverse or may notice either with equal probability. The biases in the language that we speak are affecting our thoughts while we watch the scenes and hear the utterances.

Thirdly, this project also indirectly provides evidence toward syntactic bootstrapping and semantic bootstrapping. When confronted with a novel verb in a confusing situation, it is much easier to believe that the verb is a path verb if it matches the more familiar path verb syntax. However, the ability to learn a novel verb in an unusual frame indicates evidence for semantic bootstrapping.

This project also demonstrated that a Bayesian model can be constructed that simulates the manner-path learning bias. It was shown that both syntactic and extra-syntactic evidence can be represented in the same model, and that joint scene-sentence pairs can be input, rather than just sentences or scenes. This work established an approach for providing a mechanism for accommodating changes in a learner's manner-path bias by incorporating dynamically changing prior probabilities into the model framework. The divisor in the static Bayesian model was a representation of the "normal" probability of these manner- or path-based events in the natural language tested. We concluded that the experimental subjects may be considering all the blocks they have viewed during the experiment, and setting a new standard of "normal" for manner and path verb distributions. The model was revised to take into account the changing importance of various components of the subject's bias during the experiment. Such a model successfully captured the manner-path biases of learners in the rich frame experiment, providing responses that matched reasonably well with the data. Once developed, it was demonstrated that the same model could be univer-

sally applied through comparison to a poor frame experiment data. The adjustment of initial priors was shown to be an effective approach to account for differences in syntactic frame.

Appendix A

Experimental Data

Condition	Subjects
Poor Frame 0% Manner	10
Poor Frame 25% Manner	10
Poor Frame 50% Manner	10
Poor Frame 75% Manner	10
Poor Frame 100% Manner	10
Rich Frame 0% Manner	10
Rich Frame 25% Manner	10
Rich Frame 50% Manner	16
Rich Frame 75% Manner	10
Rich Frame 100% Manner	10

Table A.1: Number of subjects in each condition.

Condition	% Manner Responses First Four Block	% Path Responses First Four Blocks	Path Bias	% Manner Responses Last Four Blocks	% Path Responses Last Four Blocks	Path Bias	Change in Path Bias
0% Path	93	8	-0.85	98	0	-0.98	-0.13
25% Path	83	5	-0.78	95	8	-0.88	-0.10
50% Path	85	3	-0.83	75	23	-0.53	0.30
75% Path	75	20	-0.55	70	33	-0.38	0.17
100% Path	43	48	0.05	8	93	0.85	0.80

Table A.2: Comparison of data across conditions for the rich frame conditions.

Condition	% Manner Responses First Four Block	% Path Responses First Four Blocks	Path Bias	% Manner Responses Last Four Blocks	% Path Responses Last Four Blocks	Path Bias	Change in Path Bias
0% Path	78	16	-0.6	95	3	-0.93	-0.33
25% Path	75	20	-0.55	88	10	-0.775	-0.23
50% Path	35	58	0.23	58	48	-0.10	-0.33
75% Path	40	45	0.05	35	80	0.45	0.4
100% Path	30	58	0.28	8	95	0.88	0.60

Table A.3: Comparison of data across conditions for the poor frame conditions.

Condition	1	2	3	4	5	6	7	8	9	10	11	12
0% Path	-0.70	-1	-1	-1	-1	-1	-0.9	-0.90	-1	-0.90	-1	-0.8
25% Path	-0.50	-0.90	-0.70	-1	-0.70	-0.80	-0.90	-0.20	-0.90	-0.80	-0.80	-1
50% Path	-0.90	-0.60	-0.60	-1	-0.40	-0.7	-1	-0.4	-0.7	-0.3	-0.6	-0.8
75% Path	-0.60	-0.80	-0.30	-0.50	-0.40	-0.40	-0.30	-0.10	-0.40	-0.40	-0.10	-0.60
100% Path	-0.70	-0.60	0.50	0.20	1	0.20	0.50	0.50	0.70	0.80	0.70	0.70

Table A.4: Path bias for rich frame conditions, by question.

Condition	1	2	3	4	5	6	7	8	9	10	11	12
0% Path	-0.3	-0.7	-0.6	-1	-0.8	-0.9	-0.9	-0.5	-1	-0.9	-0.8	-1
25% Path	-0.7	-0.6	-0.5	-1	-0.90	-1	-1	-0.50	-1	-0.80	-0.70	-0.60
50% Path	-0.30	0.70	0.30	0.20	0.10	-0.1	-0.3	-0.2	0.2	0.2	0.10	0.20
75% Path	-0.20	-0.10	0.50	0	0.60	0.70	0.40	0.40	0.30	0.70	0.60	0.60
100% Path	-0.30	0	0.7	0.1	0.8	0.6	0.6	0.7	0.8	1	0.8	0.9

Table A.5: Path bias for poor frame conditions, by question.

Question	0% Model	0% Subjects	25% Model	25% Subjects	50% Model	50% Subjects	75% Model	75% Subjects	100% Model	100% Subjects
1	-0.72	-0.7	-0.72	-0.5	-0.72	-0.9	-0.72	-0.6	-0.72	-0.7
2	-0.917	-1	-0.917	-0.9	-0.106	-0.6	-0.511	-0.8	-0.106	-0.6
3	-0.959	-1	-0.800	-0.7	-0.092	-0.6	-0.067	-0.3	0.507	0.5
4	-0.964	-1	-0.817	-1	-0.077	-1	0.374	-0.5	0.719	0.2
5	-0.962	-1	-0.898	-0.7	-0.234	-0.4	0.224	-0.4	0.761	1
6	-0.959	-1	-0.909	-0.8	-0.725	-0.7	0.601	-0.4	0.759	0.2
7	-0.956	-0.9	-0.678	-0.9	-0.708	-1	0.225	-0.3	0.747	0.5
8	-0.954	-0.9	-0.625	-0.2	-0.468	-0.4	0.123	-0.1	0.737	0.5
9	-0.952	-1	-0.821	-0.9	-0.700	-0.7	0.534	-0.4	0.729	0.7
10	-0.951	-0.9	-0.841	-0.8	-0.359	-0.3	0.161	-0.4	0.723	0.8
11	-0.951	-1	-0.554	-0.8	-0.335	-0.6	0.509	-0.1	0.719	0.7
12	-0.951	-0.8	-0.512	-1	-0.181	-0.8	0.572	-0.6	0.717	0.7

Table A.6: Rich Frame Model and Subject Comparison, by question.

Question	0% Model	0% Subjects	25% Model	25% Subjects	50% Model	50% Subjects	75% Model	75% Subjects	100% Model	100% Subjects
1	-0.39	-0.3	-0.39	-0.7	0.39	-0.3	0.39	-0.2	0.39	-0.3
2	-0.812	-0.7	-0.812	-0.6	0.373	0.7	-0.220	-0.1	0.373	0
3	-0.912	-0.6	-0.596	-0.5	0.177	0.3	0.225	0.5	0.731	0.7
4	-0.924	-1	-0.633	-1	0.023	0.2	0.611	0	0.809	0.1
5	-0.919	-0.8	-0.827	-0.9	0.004	0.1	0.400	0.6	0.815	0.8
6	-0.912	-0.9	-0.856	-1	-0.613	-0.1	0.688	0.7	0.804	0.6
7	-0.906	-0.9	-0.555	-1	-0.248	-0.3	0.328	0.4	0.793	0.6
8	-0.902	-0.5	-0.490	-0.5	-0.261	-0.2	0.237	0.4	0.783	0.7
9	-0.899	-1	-0.750	-1	-0.638	-0.2	0.600	0.3	0.777	0.8
10	-0.897	-0.8	-0.784	-0.8	-0.276	0.2	0.246	0.7	0.772	1
11	-0.896	-0.9	-0.458	-0.7	-0.234	0.1	0.570	0.6	0.769	0.8
12	-0.895	-1	-0.407	-0.6	-0.117	0.2	0.623	0.6	0.768	0.9

Table A.7: Poor Frame Model and Subject Comparison, by question.

Appendix B

Modeling Code

Abbreviation	Meaning
df	"Different Frame", i.e. Poor Frame
50_50	50% Path
qm	50% Path
qp	75% Path
r	Reverse Ordering

Table B.1: Working abbreviations for modeling

The above abbreviations are useful in understanding the remainder of the the appendices. They are concatenated into a string which represents an experimental condition. For example, `dfqmr` stands for "Different Frame Quarter Manner Reverse" which means "Poor Frame 75% Path Condition run in the reverse direction."

B.1 finalmodel.py

```
import string
from Numeric import *
import LinearAlgebra
from copy import deepcopy

# Here, the possible hypotheses and events are assigned to indices.
# Although the same index corresponds to the hypothesis and the event,
# they are given different names so that the code that references them
#  can clarify which one it's using.
HManner = 0
HPath = 1
HNeither = 2
EManner = 0
EPath = 1
ENeither = 2

# How strong are the initial priors in the memory effect?
priorEffect = 6.0

# Calculate the divisor (P(E_i)) for a given type of event.
def makeDivisor(type):
return likelihood[type][HManner]*prior[HManner] +\
           likelihood[type][HPath]*prior[HPath] +\
           likelihood[type][HNeither]*prior[HNeither]

# Define the set of stimuli for each condition.
manner = [EManner, EManner, EManner, EManner,
          EManner, EManner, EManner, EManner,
```

```
          EManner, EManner, EManner, EManner]
path = [EPath, EPath, EPath, EPath,
        EPath, EPath, EPath, EPath,
        EPath, EPath, EPath, EPath]
fiftyFifty = [EPath, EManner, EManner, EPath,
              EManner, EManner, EPath, EManner,
              EManner, EPath, EPath, EPath]
fiftyFiftyR = [EPath, EPath, EPath, EManner,
               EManner, EPath,  EManner, EManner,
               EPath, EManner, EManner, EPath]
qm = [EManner, EPath, EPath, EPath,
      EPath, EManner, EPath, EPath,
      EManner, EPath, EPath, EPath]
qmr = [EPath, EPath, EPath, EManner,
       EPath, EPath, EManner, EPath,
       EPath, EPath, EPath, EManner]
qp = [EManner, EPath, EManner, EManner,
      EManner, EManner, EPath, EManner,
      EManner, EPath, EManner, EManner]
qpr = [EManner, EManner, EPath, EManner,
       EManner, EPath, EManner, EManner,
       EManner, EManner, EPath, EManner]

allConditions = [manner, path, fiftyFifty, fiftyFiftyR,
                 qm, qmr, qp, qpr]

for condition in allConditions:
   # Set the initial priors.
   # For the poor frame, these should be set
   # to [0.56, 0.17, 0.27] instead.
```

```
prior = array([0.77, 0.05, 0.18], Float16)

# Set the likelihood values (P(H_i|E_j)).
likelihood = array([[0.72, 0.07, 0.21],
                    [0.06, 0.71, 0.23],
                    [0.22, 0.22, 0.56]], Float16)

# Initialize the event memory to the initial priors.
mcount = priorEffect*prior[HManner]
pcount = priorEffect*prior[HPath]
ncount = priorEffect*prior[HNeither]
count = priorEffect

print "Condition: %s" % condition

# Set the relative weight of the Bayesian component.
bayesweight = 1.0

# Iterate over 11 blocks. (After the 12th block, there are no more
# questions for the subject, so the human subject's bias cannot be
# determined.)
for block in range(0,11):
  bayesBias = zeros(3, Float16)
  case = condition[block]
  if case == EManner: mcount += 1
  elif case == EPath: pcount += 1
  elif case == ENeither: ncount += 1
  count += 1

  # Calculate new priors with Bayes' rule
```

```
for hypothesis in [HManner, HPath, HNeither]:
   bayesBias[hypothesis] = likelihood[case][hypothesis]\
   *prior[hypothesis]/ makeDivisor(case)

# Weighting factor
bayesweight *= .95

# Calculate the values for the memory effect
memoryBias = zeros(3, Float16)
memoryBias[EManner] = mcount/count
memoryBias[EPath] = pcount/count
memoryBias[ENeither] = ncount/count

# Set the new bias to the weighted average of bayesBias
# and memoryBias
newBias = (bayesweight)*bayesBias + (1-bayesweight)*memoryBias
prior = newBias
print "%s: %s, bias value: %s" % (block+1, newBias,
  prior[HPath]-prior[HManner])
```

Appendix C

Experimental Scripts

C.1 Rich Frame

C.1.1 Rich Frame 0% Path

<Train>
She is going rapple across the path.
Hop2 Across.mov
</Train>
<Test>
Is this rappleing?
Hop2 Out.mov
Is this rappleing?
Flap Across.mov
Is this rappleing?
Hop2 Out.mov
Is this rappleing?
Flap Across.mov
</Test>
<Train>
She is going to rapple into the room.
Hop2 In.mov
She is going to rapple up the stairs.
Hop2 Up.mov
He is going to rapple along the table.
Hop2 Along.mov
She is going to rapple in the lounge.
Hop2 Turn.mov
She is going rapple down the ramp.
Hop2 Down.mov
</Train>
<Test>
Is this rappleing?
Stoop Across.mov
Is this rappleing?
Hop2 Front.mov
Is this rappleing?
Stoop Across.mov
Is this rappleing?
Hop2 Front.mov
</Test>
<Train>
She is going to bamp between the chairs.
Crawl Between.mov
</Train>
<Test>
Is this bamping?
Stoop Between.mov
Is this bamping?
Crawl Around.mov
Is this bamping?
Stoop Between.mov
Is this bamping?
Crawl Around.mov
</Test>
<Train>
She is going to bamp up the hill.
Crawl Up.mov
She is going to bamp behind the chair.
Crawl Behind.mov
She is going to bamp in the hall.
Crawl Turn.mov
She is going to bamp into the museaum.
Crawl In2.mov
She is going to bamp over the stone.
Crawl Over.mov
</Train>
<Test>
Is this bamping?
Crawl Along.mov
Is this bamping?
Tiptoe Between.mov
Is this bamping?
Crawl Along.mov
Is this bamping?
Tiptoe Between.mov
</Test>
<Train>
She is going to minje over the bench.
Dance Over.mov
</Train>
<Test>
Is this minjing?
Dance In.mov
Is this minjing?
Hop2 Over.mov
Is this minjing?
Dance In.mov
Is this minjing?
Hop2 Over.mov
</Test>
<Train>
She is going to minje across the path.
Dance Across.mov
She is going to minje down the stairs.
Dance Down.mov
She is going to minje in front of the TV.
Dance Front.mov
She is going to minje out of the garden.
Dance Out.mov
She is going to minje around the tree.
Dance Around.mov
</Train>
<Test>
Is this minjing?
March Over.mov
Is this minjing?
Dance Along.mov
Is this minjing?
March Over.mov
Is this minjing?
Dance Along.mov
</Test>
<Train>
She is going to morp from the kitchen.
Crab Out.mov
</Train>
<Test>
Is this morping?
Crab Behind.mov
Is this morping?
Run Out.mov
Is this morping?

Crab Behind.mov
Is this morping?
Run Out.mov
</Test>
<Train>
She is going to morp in front of the chair.
Crab Front.mov
She is going to morp through the door.
Crab In.mov
She is going to morp between the chairs.
Crab Between.mov
She is going to morp across the path.
Crab Across.mov
She is going to morp around the hall.
Crab Turn.mov
</Train>
<Test>
Is this morping?
March Out.mov
Is this morping?
Crab Along.mov
Is this morping?
March Out.mov
Is this morping?
Crab Along.mov
</Test>
<Train>
She is going to torg up the slide.
Flap Up.mov
</Train>
<Test>
Is this torging?
Walk Up.mov
Is this torging?
Flap Between.mov
Is this torging?
Walk Up.mov
Is this torging?
Flap Between.mov
</Test>
<Train>
She is going to torg down the ramp.
Flap Down.mov
She is going to torg around the lamp post.
Flap Around.mov
She is going to torg into the building.
Flap In.mov
She is going to torg in front of the picnic table.
Flap Front.mov
She is going to torg over the barrier.
Flap Over.mov
</Train>
<Test>
Is this torging?
Flap Turn.mov
Is this torging?
Hop2 Up.mov
Is this torging?
Flap Turn.mov
Is this torging?
Hop2 Up.mov
</Test>
<Train>
She is going to floop in front of the TV.
Tiptoe Front.mov
</Train>
<Test>
Is this flooping?
Tiptoe Turn.mov
Is this flooping?
March Front.mov
Is this flooping?
Tiptoe Turn.mov
Is this flooping?
March Front.mov
</Test>
<Train>
She is going to floop around the bush.
Tiptoe Around.mov
She is going to floop over the green bench.
Tiptoe Over.mov
She is going to floop into the house.
Tiptoe In.mov
She is going to floop up the stairs.
Tiptoe Up.mov
She is going to floop out the door.
Tiptoe Out.mov
</Train>
<Test>
Is this flooping?
Stoop Front.mov
Is this flooping?
Tiptoe Down.mov
Is this flooping?
Stoop Front.mov
Is this flooping?
Tiptoe Down.mov
</Test>
<Train>
She is going to plamp along the hedge.
Hop1 Along.mov
</Train>
<Test>
Is this plamping?
Hop1 Around.mov
Is this plamping?
Flap Along.mov
Is this plamping?
Hop1 Around.mov
Is this plamping?
Flap Along.mov
</Test>
<Train>
He is going to plamp out of the room.
Hop1 Out.mov
She is going to plamp across the hall.
Hop1 Across.mov
She is going to plamp between the cars.
Hop1 Between.mov
She is going to plamp up the ramp.
Hop1 Up.mov
She is going to plamp through the door.

Hop1 In.mov
</Train>
<Test>
Is this plamping?
Stoop Along.mov
Is this plamping?
Hop1 Over.mov
Is this plamping?
Stoop Along.mov
Is this plamping?
Hop1 Over.mov
</Test>
<Train>
She is going to gleck in the lounge.
March Turn.mov
</Train>
<Test>
Is this glecking?
Run Turn.mov
Is this glecking?
March Up.mov
Is this glecking?
Run Turn.mov
Is this glecking?
March Up.mov
</Test>
<Train>
He is going to gleck behind the chair.
March Behind.mov
She is going to gleck out the door.
March Out.mov
She is going to gleck across the road.
March Across.mov
She is going to gleck around the chair.
March Around.mov
She is going to gleck between the garbage cans.
March Between.mov
</Train>
<Test>
Is this glecking?
Dance Turn.mov
Is this glecking?
March Down.mov
Is this glecking?
Dance Turn.mov
Is this glecking?
March Down.mov
</Test>
<Train>
She is going to birk into the garden.
Skip In.mov
</Train>
<Test>
Is this birking?
Skip Front.mov
Is this birking?
Stoop In.mov
Is this birking?
Skip Front.mov
Is this birking?
Stoop In.mov
</Test>
<Train>
She is going to birk between the cars.
Skip Between.mov
She is going to birk up the hill.
Skip Up.mov
She is going to birk from the room.
Skip Out.mov
She is going to birk beside the wall.
Skip Along.mov
He is going to birk across the path.
Skip Across.mov
</Train>
<Test>
Is this birking?
Crawl In.mov
Is this birking?
Skip Over.mov
Is this birking?
Crawl In.mov
Is this birking?
Skip Over.mov
</Test>
<Train>
She is going to molk around the chair.
Walk Around.mov
</Train>
<Test>
Is this molking?
Walk Down.mov
Is this molking?
Run Around.mov
Is this molking?
Walk Down.mov
Is this molking?
Run Around.mov
</Test>
<Train>
She is going to molk over the picnic table.
Walk Over.mov
She is going to molk around the garden.
Walk Turn.mov
She is going to molk in front of the green chair.
Walk Front.mov
She is going to molk between the chairs.
Walk Between.mov
She is going to molk behind the magnifying glass.
Walk Behind.mov
</Train>
<Test>
Is this molking?
Walk Out.mov
Is this molking?
Crab Around.mov
Is this molking?
Walk Out.mov
Is this molking?
Crab Around.mov
</Test>
<Train>
She is going to belf down the hill.

Stoop Down.mov
</Train>
<Test>
Is this belfing?
Crawl Down.mov
Is this belfing?
Stoop Around.mov
Is this belfing?
Crawl Down.mov
Is this belfing?
Stoop Around.mov
</Test>
<Train>
She is going to belf around the lawn.
Stoop Turn.mov
He is going to belf above the hallway.
Stoop Over.mov
He is going to belf behind the TV.
Stoop Behind.mov
She is going to belf from the building.
Stoop Out.mov
She is going to belf into the hall.
Stoop In2.mov
</Train>
<Test>
Is this belfing?
Stoop Up.mov
Is this belfing?
Hop1 Down.mov
Is this belfing?
Stoop Up.mov
Is this belfing?
Hop1 Down.mov
</Test>
<Train>
She is going to freen behind the sign.
Run Behind.mov
</Train>
<Test>
Is this freening?
Tiptoe Behind.mov
Is this freening?
Run Along.mov
Is this freening?
Tiptoe Behind.mov
Is this freening?
Run Along.mov
</Test>
<Train>
She is going to freen over the telephone books.
Run Over.mov
She is going to freen in front of the desk.
Run Front.mov
She is going to freen around the tree.
Run Around.mov
She is going to freen into the church.
Run In.mov
He is going to freen down the ramp.
Run Down.mov
</Train>
<Test>
Is this freening?
Run Across.mov
Is this freening?
Dance Behind.mov
Is this freening?
Run Across.mov
Is this freening?
Dance Behind.mov
</Test>

C.1.2 Rich Frame 25% Path

<Train>
She is going rapple across the path.
Hop2 Across.mov
</Train>
<Test>
Is this rappleing?
Hop2 Out.mov
Is this rappleing?
Flap Across.mov
</Test>
<Train>
She is going to rapple into the room.
Hop2 In.mov
She is going to rapple up the stairs.
Hop2 Up.mov
He is going to rapple along the table.
Hop2 Along.mov
She is going to rapple in the lounge.
Hop2 Turn.mov
She is going rapple down the ramp.
Hop2 Down.mov
</Train>
<Test>
Is this rappleing?
Stoop Across.mov
Is this rappleing?
Hop2 Front.mov
</Test>
<Train>
She is going to bamp between the chairs.
Crawl Between.mov
</Train>
<Test>
Is this bamping?
Stoop Between.mov
Is this bamping?
Crawl Around.mov
</Test>
<Train>
She is going to bamp between the cars.
Skip Between.mov
She is going to bamp between the garbage cans.
March Between.mov
She is going to bamp between the chairs.
Crab Between.mov
She is going to bamp between the chairs.
Walk Between.mov
She is going to bamp between the cars.
Hop1 Between.mov
</Train>
<Test>
Is this bamping?
Crawl Along.mov
Is this bamping?
Tiptoe Between.mov
</Test>
<Train>
She is going to minje over the bench.
Dance Over.mov
</Train>
<Test>
Is this minjing?
Dance In.mov
Is this minjing?
Hop2 Over.mov
</Test>
<Train>
She is going to minje across the path.
Dance Across.mov
She is going to minje down the stairs.
Dance Down.mov
She is going to minje in front of the TV.
Dance Front.mov
She is going to minje out of the garden.
Dance Out.mov
She is going to minje around the tree.
Dance Around.mov
</Train>
<Test>
Is this minjing?
March Over.mov
Is this minjing?
Dance Along.mov
</Test>
<Train>
She is going to morp from the kitchen.
Crab Out.mov
</Train>
<Test>
Is this morping?
Crab Behind.mov
Is this morping?
Run Out.mov
</Test>
<Train>
She is going to morp in front of the chair.
Crab Front.mov
She is going to morp through the door.
Crab In.mov
She is going to morp between the chairs.
Crab Between.mov
She is going to morp across the path.
Crab Across.mov
She is going to morp around the hall.
Crab Turn.mov
</Train>
<Test>
Is this morping?
March Out.mov
Is this morping?
Crab Along.mov
</Test>
<Train>
She is going to torg up the slide.
Flap Up.mov
</Train>
<Test>
Is this torging?
Walk Up.mov
Is this torging?
Flap Between.mov

</Test>
<Train>
She is going to torg down the ramp.
Flap Down.mov
She is going to torg around the lamp post.
Flap Around.mov
She is going to torg into the building.
Flap In.mov
She is going to torg in front of the picnic table.
Flap Front.mov
She is going to torg over the barrier.
Flap Over.mov
</Train>
<Test>
Is this torging?
Flap Turn.mov
Is this torging?
Hop2 Up.mov
</Test>
<Train>
She is going to floop in front of the TV.
Tiptoe Front.mov
</Train>
<Test>
Is this flooping?
Tiptoe Turn.mov
Is this flooping?
March Front.mov
</Test>
<Train>
She is going to floop around the bush.
Tiptoe Around.mov
She is going to floop over the green bench.
Tiptoe Over.mov
She is going to floop into the house.
Tiptoe In.mov
She is going to floop up the stairs.
Tiptoe Up.mov
She is going to floop out the door.
Tiptoe Out.mov
</Train>
<Test>
Is this flooping?
Stoop Front.mov
Is this flooping?
Tiptoe Down.mov
</Test>
<Train>
She is going to plamp along the hedge.
Hop1 Along.mov
</Train>
<Test>
Is this plamping?
Hop1 Around.mov
Is this plamping?
Flap Along.mov
</Test>
<Train>
He is going to plamp along the table.
Hop2 Along.mov
She is going to plamp along the hedge.
Walk Along2.mov
She is going to plamp along the chalk board.
Run Along.mov
She is going to plamp along the hedge.
Skip Along2.mov
She is going to plamp along the stone wall.
Walk Along.mov
</Train>
<Test>
Is this plamping?
Stoop Along.mov
Is this plamping?
Hop1 Over.mov
</Test>
<Train>
She is going to gleck in the lounge.
March Turn.mov
</Train>
<Test>
Is this glecking?
Run Turn.mov
Is this glecking?
March Up.mov
</Test>
<Train>
He is going to gleck behind the chair.
March Behind.mov
She is going to gleck out the door.
March Out.mov
She is going to gleck across the road.
March Across.mov
She is going to gleck around the chair.
March Around.mov
She is going to gleck between the garbage cans.
March Between.mov
</Train>
<Test>
Is this glecking?
Dance Turn.mov
Is this glecking?
March Down.mov
</Test>
<Train>
She is going to birk into the garden.
Skip In.mov
</Train>
<Test>
Is this birking?
Skip Front.mov
Is this birking?
Stoop In.mov
</Test>
<Train>
She is going to birk between the cars.
Skip Between.mov
She is going to birk up the hill.
Skip Up.mov
She is going to birk from the room.
Skip Out.mov
She is going to birk beside the wall.
Skip Along.mov

He is going to birk across the path.
Skip Across.mov
</Train>
<Test>
Is this birking?
Crawl In.mov
Is this birking?
Skip Over.mov
</Test>
<Train>
She is going to molk around the chair.
Walk Around.mov
</Train>
<Test>
Is this molking?
Walk Down.mov
Is this molking?
Run Around.mov
</Test>
<Train>
She is going to molk around the tree.
Dance Around.mov
She is going to molk around the bush.
Tiptoe Around.mov
She is going to molk around the oak.
Hop2 Around.mov
She is going to molk around the chair.
March Around.mov
She is going to molk around the lamp post.
Flap Around.mov
</Train>
<Test>
Is this molking?
Walk Out.mov
Is this molking?
Crab Around.mov
</Test>
<Train>
She is going to belf down the hill.
Stoop Down.mov
</Train>
<Test>
Is this belfing?
Crawl Down.mov
Is this belfing?
Stoop Around.mov
</Test>
<Train>
She is going to belf around the lawn.
Stoop Turn.mov
He is going to belf above the hallway.
Stoop Over.mov
He is going to belf behind the TV.
Stoop Behind.mov
She is going to belf from the building.
Stoop Out.mov
She is going to belf into the hall.
Stoop In2.mov
</Train>
<Test>
Is this belfing?
Stoop Up.mov
Is this belfing?
Hop1 Down.mov
</Test>
<Train>
She is going to freen behind the sign.
Run Behind.mov
</Train>
<Test>
Is this freening?
Tiptoe Behind.mov
Is this freening?
Run Along.mov
</Test>
<Train>
She is going to freen over the telephone books.
Run Over.mov
She is going to freen in front of the desk.
Run Front.mov
She is going to freen around the tree.
Run Around.mov
She is going to freen into the church.
Run In.mov
He is going to freen down the ramp.
Run Down.mov
</Train>
<Test>
Is this freening?
Run Across.mov
Is this freening?
Dance Behind.mov
</Test>

C.1.3 Rich Frame 50% Path

<Train>
She is going to rapple across the path.
Hop2 Across.mov
</Train>
<Test>
Is this rappling?
Hop2 Out.mov
Is this rappling?
Flap Across.mov
</Test>
<Train>
She is going to rapple across the hall.
Hop1 Across.mov
She is going to rapple across the path.
Stoop Across.mov
She is going to rapple across the path.
Dance Across.mov
She is going to rapple across the sand box.
Walk Across.mov
She is going to rapple across the path.
Skip Across.mov
</Train>
<Test>
Is this rappling?
Crab Across.mov
Is this rappling?
Hop2 Front.mov
</Test>
<Train>
She is going to bamp between between the chairs.
Crawl Between.mov
</Train>
<Test>
Is this bamping?
Stoop Between.mov
Is this bamping?
Crawl Around.mov
</Test>
<Train>
She is going to bamp up the hill.
Crawl Up.mov
She is going to bamp behind the chair.
Crawl Behind.mov
She is going to bamp around the hall.
Crawl Turn.mov
She is going to bamp into the museum.
Crawl In2.mov
She is going to bamp over the stone.
Crawl Over.mov
</Train>
<Test>
Is this bamping?
Crawl Along.mov
Is this bamping?
Tiptoe Between.mov
</Test>
<Train>
She is going to minje over the bench.
Dance Over.mov
</Train>
<Test>
Is this minjing?
Dance In.mov
Is this minjing?
Hop2 Over.mov
</Test>
<Train>
She is going to minje across the path.
Dance Across.mov
She is going to minje down the stairs.
Dance Down.mov
She is going to minje in front of the TV.
Dance Front.mov
He is going to minje out of the garden.
Dance Out.mov
She is going to minje around the tree.
Dance Around.mov
</Train>
<Test>
Is this minjing?
March Over.mov
Is this minjing?
Dance Along.mov
</Test>
<Train>
She is going to morp out of the kitchen.
Crab Out.mov
</Train>
<Test>
Is this morping?
Crab Behind.mov
Is this morping?
Run Out.mov
</Test>
<Train>
He is going to morp from the room.
Hop1 Out.mov
She is going to morp out the gate.
Dance Out.mov
She is going to morp from the lab.
Walk Out.mov
She is going to morp out of the hall.
Skip Out.mov
She is going to morp out of the building.
Stoop Out.mov
</Train>
<Test>
Is this morping?
March Out.mov
Is this morping?
Crab Along.mov
</Test>
<Train>
She is going to torg up the slide.
Flap Up.mov
</Train>
<Test>
Is this torging?
Walk Up.mov
Is this torging?
Flap Between.mov

</Test>
<Train>
She is going to torg down the ramp.
Flap Down.mov
She is going to torg around the lamp post.
Flap Around.mov
She is going to torg into the building.
Flap In.mov
She is going to torg in front of the picnic table.
Flap Front.mov
She is going to torg over the barier.
Flap Over.mov
</Train>
<Test>
Is this torging?
Flap Turn.mov
Is this torging?
Hop2 Up.mov
</Test>
<Train>
She is going to floop in front of the TV.
Tiptoe Front.mov
</Train>
<Test>
Is this flooping?
Tiptoe Turn.mov
Is this flooping?
March Front.mov
</Test>
<Train>
She is going to floop around the bush.
Tiptoe Around.mov
She is going to floop over the green bench.
Tiptoe Over.mov
She is going to floop into the house.
Tiptoe In.mov
She is going to floop up the stairs.
Tiptoe Up.mov
She is going to floop out the door.
Tiptoe Out.mov
</Train>
<Test>
Is this flooping?
Stoop Front.mov
Is this flooping?
Tiptoe Down.mov
</Test>
<Train>
She is going to plamp along the hedge.
Hop1 Along.mov
</Train>
<Test>
Is this plamping?
Hop1 Around.mov
Is this plamping?
Flap Along.mov
</Test>
<Train>
She is going to plamp along the stone wall.
Dance Along.mov
She is going to plamp along the wall.
Skip Along.mov
She is going to plamp along the hedge.
Walk Along2.mov
She is going to plamp along the blackboard.
Run Along.mov
She is going to plamp along the stone wall.
Walk Along.mov
</Train>
<Test>
Is this plamping?
Stoop Along.mov
Is this plamping?
Hop1 Over.mov
</Test>
<Train>
She is going to gleck in the lounge.
March Turn.mov
</Train>
<Test>
Is this glecking?
Run Turn.mov
Is this glecking?
March Up.mov
</Test>
<Train>
He is going to gleck behind the chair.
March Behind.mov
She is going to gleck out the door.
March Out.mov
She is going to gleck across the road.
March Across.mov
She is going to gleck around the chair.
March Around.mov
She is going to gleck between the garbage cans.
March Between.mov
</Train>
<Test>
Is this glecking?
Dance Turn.mov
Is this glecking?
March Down.mov
</Test>
<Train>
She is going to birk into the garden.
Skip In.mov
</Train>
<Test>
Is this birking?
Skip Front.mov
Is this birking?
Stoop In.mov
</Test>
<Train>
She is going to birk between the cars.
Skip Between.mov
She is going to birk up the hill.
Skip Up.mov
She is going to birk from the room.
Skip Out.mov
She is going to birk beside the wall.
Skip Along.mov

He is going to birk across the path.
Skip Across.mov
</Train>
<Test>
Is this birking?
Crawl In.mov
Is this birking?
Skip Over.mov
</Test>
<Train>
She is going to molk around the chair.
Walk Around.mov
</Train>
<Test>
Is this molking?
Walk Down.mov
Is this molking?
Run Around.mov
</Test>
<Train>
She is going to molk around the tree.
Dance Around.mov
She is going to molk around the bush.
Tiptoe Around.mov
She is going to molk around the oak.
Hop2 Around.mov
She is going to molk around the chair.
March Around.mov
She is going to molk around the lamp post.
Flap Around.mov
</Train>
<Test>
Is this molking?
Walk Out.mov
Is this molking?
Crab Around.mov
</Test>
<Train>
She is going to belf down the hill.
Stoop Down.mov
</Train>
<Test>
Is this belfing?
Crawl Down.mov
Is this belfing?
Stoop Around.mov
</Test>
<Train>
She is going to belf down the slide.
Tiptoe Down.mov
She is going to belf down the ramp.
Crawl Down.mov
She is going to belf down the stairs.
Dance Down.mov
She is going to belf down the hill.
Crab Down.mov
He is going to belf down the stairs.
Walk Down.mov
</Train>
<Test>
Is this belfing?
Stoop Up.mov
Is this belfing?
Hop1 Down.mov
</Test>
<Train>
She is going to freen behind the sign.
Run Behind.mov
</Train>
<Test>
Is this freening?
Tiptoe Behind.mov
Is this freening?
Run Along.mov
</Test>
<Train>
She is going to freen behind the cart.
Hop1 Behind.mov
He is going to freen behind the chair
March Behind.mov
She is going to freen behind the sign board.
Crab Behind.mov
He is going to freen behind the garbage can.
Dance Behind.mov
He is going to freen behind the chair.
Skip Behind.mov
</Train>
<Test>
Is this freening?
Run Across.mov
Is this freening?
Stoop Behind.mov
</Test>

C.1.4 Rich Frame 75% Path

<Train>
She is going rapple across the path.
Hop2 Across.mov
</Train>
<Test>
Is this rappleing?
Hop2 Out.mov
Is this rappleing?
Flap Across.mov
</Test>
<Train>
She is going to rapple into the room.
Hop2 In.mov
She is going to rapple up the stairs.
Hop2 Up.mov
He is going to rapple along the table.
Hop2 Along.mov
She is going to rapple in the lounge.
Hop2 Turn.mov
She is going rapple down the ramp.
Hop2 Down.mov
</Train>
<Test>
Is this rappleing?
Stoop Across.mov
Is this rappleing?
Hop2 Front.mov
</Test>
<Train>
She is going to bamp between the chairs.
Crawl Between.mov
</Train>
<Test>
Is this bamping?
Stoop Between.mov
Is this bamping?
Crawl Around.mov
</Test>
<Train>
She is going to bamp between the cars.
Skip Between.mov
She is going to bamp between the garbage cans.
March Between.mov
She is going to bamp between the chairs.
Crab Between.mov
She is going to bamp between the chairs.
Walk Between.mov
She is going to bamp between the cars.
Hop1 Between.mov
</Train>
<Test>
Is this bamping?
Crawl Along.mov
Is this bamping?
Tiptoe Between.mov
</Test>
<Train>
She is going to minje over the bench.
Dance Over.mov
</Train>
<Test>
Is this minjing?
Dance In.mov
Is this minjing?
Hop2 Over.mov
</Test>
<Train>
She is going to minje across the path.
Dance Across.mov
She is going to minje down the stairs.
Dance Down.mov
She is going to minje in front of the TV.
Dance Front.mov
She is going to minje out of the garden.
Dance Out.mov
She is going to minje around the tree.
Dance Around.mov
</Train>
<Test>
Is this minjing?
March Over.mov
Is this minjing?
Dance Along.mov
</Test>
<Train>
She is going to morp from the kitchen.
Crab Out.mov
</Train>
<Test>
Is this morping?
Crab Behind.mov
Is this morping?
Run Out.mov
</Test>
<Train>
She is going to morp in front of the chair.
Crab Front.mov
She is going to morp through the door.
Crab In.mov
She is going to morp between the chairs.
Crab Between.mov
She is going to morp across the path.
Crab Across.mov
She is going to morp around the hall.
Crab Turn.mov
</Train>
<Test>
Is this morping?
March Out.mov
Is this morping?
Crab Along.mov
</Test>
<Train>
She is going to torg up the slide.
Flap Up.mov
</Train>
<Test>
Is this torging?
Walk Up.mov
Is this torging?
Flap Between.mov

</Test>
<Train>
She is going to torg down the ramp.
Flap Down.mov
She is going to torg around the lamp post.
Flap Around.mov
She is going to torg into the building.
Flap In.mov
She is going to torg in front of the picnic table.
Flap Front.mov
She is going to torg over the barrier.
Flap Over.mov
</Train>
<Test>
Is this torging?
Flap Turn.mov
Is this torging?
Hop2 Up.mov
</Test>
<Train>
She is going to floop in front of the TV.
Tiptoe Front.mov
</Train>
<Test>
Is this flooping?
Tiptoe Turn.mov
Is this flooping?
March Front.mov
</Test>
<Train>
She is going to floop around the bush.
Tiptoe Around.mov
She is going to floop over the green bench.
Tiptoe Over.mov
She is going to floop into the house.
Tiptoe In.mov
She is going to floop up the stairs.
Tiptoe Up.mov
She is going to floop out the door.
Tiptoe Out.mov
</Train>
<Test>
Is this flooping?
Stoop Front.mov
Is this flooping?
Tiptoe Down.mov
</Test>
<Train>
She is going to plamp along the hedge.
Hop1 Along.mov
</Train>
<Test>
Is this plamping?
Hop1 Around.mov
Is this plamping?
Flap Along.mov
</Test>
<Train>
He is going to plamp along the table.
Hop2 Along.mov
She is going to plamp along the hedge.
Walk Along2.mov
She is going to plamp along the chalk board.
Run Along.mov
She is going to plamp along the hedge.
Skip Along2.mov
She is going to plamp along the stone wall.
Walk Along.mov
</Train>
<Test>
Is this plamping?
Stoop Along.mov
Is this plamping?
Hop1 Over.mov
</Test>
<Train>
She is going to gleck in the lounge.
March Turn.mov
</Train>
<Test>
Is this glecking?
Run Turn.mov
Is this glecking?
March Up.mov
</Test>
<Train>
He is going to gleck behind the chair.
March Behind.mov
She is going to gleck out the door.
March Out.mov
She is going to gleck across the road.
March Across.mov
She is going to gleck around the chair.
March Around.mov
She is going to gleck between the garbage cans.
March Between.mov
</Train>
<Test>
Is this glecking?
Dance Turn.mov
Is this glecking?
March Down.mov
</Test>
<Train>
She is going to birk into the garden.
Skip In.mov
</Train>
<Test>
Is this birking?
Skip Front.mov
Is this birking?
Stoop In.mov
</Test>
<Train>
She is going to birk between the cars.
Skip Between.mov
She is going to birk up the hill.
Skip Up.mov
She is going to birk from the room.
Skip Out.mov
She is going to birk beside the wall.
Skip Along.mov

He is going to birk across the path.
Skip Across.mov
</Train>
<Test>
Is this birking?
Crawl In.mov
Is this birking?
Skip Over.mov
</Test>
<Train>
She is going to molk around the chair.
Walk Around.mov
</Train>
<Test>
Is this molking?
Walk Down.mov
Is this molking?
Run Around.mov
</Test>
<Train>
She is going to molk around the tree.
Dance Around.mov
She is going to molk around the bush.
Tiptoe Around.mov
She is going to molk around the oak.
Hop2 Around.mov
She is going to molk around the chair.
March Around.mov
She is going to molk around the lamp post.
Flap Around.mov
</Train>
<Test>
Is this molking?
Walk Out.mov
Is this molking?
Crab Around.mov
</Test>
<Train>
She is going to belf down the hill.
Stoop Down.mov
</Train>
<Test>
Is this belfing?
Crawl Down.mov
Is this belfing?
Stoop Around.mov
</Test>
<Train>
She is going to belf around the lawn.
Stoop Turn.mov
He is going to belf above the hallway.
Stoop Over.mov
He is going to belf behind the TV.
Stoop Behind.mov
She is going to belf from the building.
Stoop Out.mov
She is going to belf into the hall.
Stoop In2.mov
</Train>
<Test>
Is this belfing?
Stoop Up.mov
Is this belfing?
Hop1 Down.mov
</Test>
<Train>
She is going to freen behind the sign.
Run Behind.mov
</Train>
<Test>
Is this freening?
Tiptoe Behind.mov
Is this freening?
Run Along.mov
</Test>
<Train>
She is going to freen over the telephone books.
Run Over.mov
She is going to freen in front of the desk.
Run Front.mov
She is going to freen around the tree.
Run Around.mov
She is going to freen into the church.
Run In.mov
He is going to freen down the ramp.
Run Down.mov
</Train>
<Test>
Is this freening?
Run Across.mov
Is this freening?
Dance Behind.mov
</Test>

C.1.5 Rich Frame 100% Path

<Train>
She is going to rapple across the path.
Hop2 Across.mov
</Train>
<Test>
Is this rappleing?
Hop2 Out.mov
Is this rappleing?
Flap Across.mov
</Test>
<Train>
She is going to rapple across the sand box.
Walk Across.mov
She is going to rapple across the path.
Dance Across.mov
She is going to rapple the path.
Crab Across.mov
He is going to rapple across the sidewalk.
Skip Across.mov
She is going to rapple across the hall.
Hop1 Across.mov
</Train>
<Test>
Is this rappleing?
Stoop Across.mov
Is this rappleing?
Hop2 Front.mov
</Test>
<Train>
She is going to bamp between the chairs.
Crawl Between.mov
</Train>
<Test>
Is this bamping?
Stoop Between.mov
Is this bamping?
Crawl Around.mov
</Test>
<Train>
She is going to bamp between the cars.
Skip Between.mov
She is going to bamp between the garbage cans.
March Between.mov
She is going to bamp between the chairs.
Crab Between.mov
She is going to bamp between the chairs.
Walk Between.mov
She is going to bamp between the cars.
Hop1 Between.mov
</Train>
<Test>
Is this bamping?
Crawl Along.mov
Is this bamping?
Tiptoe Between.mov
</Test>
<Train>
She is going to minje over the bench.
Dance Over.mov
</Train>
<Test>
Is this minjing?
Dance In.mov
Is this minjing?
Hop2 Over.mov
</Test>
<Train>
She is going to minje over the phone books.
Run Over.mov
She is going to minje over the bench.
Tiptoe Over.mov
She is going to minje over the barrier.
Flap Over.mov
She is going to minje over a rock.
Crawl Over.mov
She is going to minje over the picnic table.
Walk Over.mov
</Train>
<Test>
Is this minjing?
March Over.mov
Is this minjing?
Dance Along.mov
</Test>
<Train>
She is going to morp from the kitchen.
Crab Out.mov
</Train>
<Test>
Is this morping?
Crab Behind.mov
Is this morping?
Run Out.mov
</Test>
<Train>
He is going to morp from the room.
Hop1 Out.mov
She is going to morp from the lab.
Tiptoe Out.mov
She is going to morp out of the hall.
Skip Out.mov
She is going to morp out the building.
Stoop Out.mov
She is going to morp out of the garden.
Dance Out.mov
</Train>
<Test>
Is this morping?
March Out.mov
Is this morping?
Crab Along.mov
</Test>
<Train>
She is going to torg up the slide.
Flap Up.mov
</Train>
<Test>
Is this torging?
Walk Up.mov
Is this torging?
Flap Between.mov

</Test>
<Train>
She is going to torg up the stairs.
Tiptoe Up.mov
She is going to torg up the hill.
Skip Up.mov
She is going to torg up the steps.
Crawl Up2.mov
She is going to torg up the ramp.
Hop1 Up.mov
She is going torg up the hill.
Crawl Up.mov
</Train>
<Test>
Is this torging?
Flap Turn.mov
Is this torging?
Hop2 Up.mov
</Test>
<Train>
She is going to floop in front of the TV cart.
Tiptoe Front.mov
</Train>
<Test>
Is this flooping?
Tiptoe Turn.mov
Is this flooping?
March Front.mov
</Test>
<Train>
She is going to floop in front of the green chair.
Walk Front.mov
She is going to floop in front of the picnic table.
Flap Front.mov
She is going to floop in front of the TV cart.
Dance Front.mov
She is going to floop in front of the desk.
Run Front.mov
She is going to floop in front of the sign.
Crab Front.mov
</Train>
<Test>
Is this flooping?
Stoop Front.mov
Is this flooping?
Tiptoe Down.mov
</Test>
<Train>
She is going to plamp along the hedge.
Hop1 Along.mov
</Train>
<Test>
Is this plamping?
Hop1 Around.mov
Is this plamping?
Flap Along.mov
</Test>
<Train>
He is going to plamp along the table.
Hop2 Along.mov
She is going to plamp along the hedge.
Walk Along2.mov
She is going to plamp along the chalk board.
Run Along.mov
She is going to plamp along the hedge.
Skip Along2.mov
She is going to plamp along the stone wall.
Walk Along.mov
</Train>
<Test>
Is this plamping?
Stoop Along.mov
Is this plamping?
Hop1 Over.mov
</Test>
<Train>
She is going to gleck around the lounge.
March Turn.mov
</Train>
<Test>
Is this glecking?
Run Turn.mov
Is this glecking?
March Up.mov
</Test>
<Train>
She is going to gleck around the grass.
Stoop Turn.mov
She is going to gleck around the hallway.
Crawl Turn.mov
She is going to gleck around the garden.
Hop1 Turn.mov
She is going to gleck around the garden.
Walk Turn.mov
She is going to gleck around the lounge.
Hop2 Turn.mov
</Train>
<Test>
Is this glecking?
Dance Turn.mov
Is this glecking?
March Down.mov
</Test>
<Train>
She is going to birk into the garden.
Skip In.mov
</Train>
<Test>
Is this birking?
Skip Front.mov
Is this birking?
Stoop In.mov
</Test>
<Train>
She is going to birk into the church.
Flap In.mov
She is going to birk into the lab.
Hop2 In.mov
She is going to birk into the house.
Tiptoe In.mov
She is going to birk into the church.
Run In.mov

She is going to birk into museum.
Hop1 In.mov
</Train>
<Test>
Is this birking?
Crawl In.mov
Is this birking?
Skip Over.mov
</Test>
<Train>
She is going to molk around the chair.
Walk Around.mov
</Train>
<Test>
Is this molking?
Walk Down.mov
Is this molking?
Run Around.mov
</Test>
<Train>
She is going to molk around the tree.
Dance Around.mov
She is going to molk around the bush.
Tiptoe Around.mov
She is going to molk around the oak.
Hop2 Around.mov
She is going to molk around the chair.
March Around.mov
She is going to molk around the lamp post.
Flap Around.mov
</Train>
<Test>
Is this molking?
Walk Out.mov
Is this molking?
Crab Around.mov
</Test>
<Train>
She is going to belf down the hill.
Stoop Down.mov
</Train>
<Test>
Is this belfing?
Crawl Down.mov
Is this belfing?
Stoop Around.mov
</Test>
<Train>
She is going to belf down the ramp.
Flap Down.mov
She is going to belf down the ramp.
March Down.mov
She is going to belf down the stairs.
Dance Down.mov
She is going to belf down the ramp.
Hop2 Down.mov
She is going to belf down the hill.
Crab Down.mov
</Train>
<Test>
Is this belfing?
Stoop Up.mov
Is this belfing?
Hop1 Down.mov
</Test>
<Train>
She is going to freen behind the sign.
Run Behind.mov
</Train>
<Test>
Is this freening?
Tiptoe Behind.mov
Is this freening?
Run Along.mov
</Test>
<Train>
He is going to freen behind the chair.
Skip Behind.mov
She is going to freen behind the cart.
Hop1 Behind.mov
She is going to freen behind the chair.
Crawl Behind.mov
She is going to freen behind the TV.
Stoop Behind.mov
He is going to freen behind the chair.
March Behind.mov
</Train>
<Test>
Is this freening?
Run Across.mov
Is this freening?
Dance Behind.mov
</Test>

C.2 Poor Frame

C.2.1 Poor Frame 0% Path

<Train>
She is going rapple the path.
Hop2 Across.mov
</Train>
<Test>
Is this rappleing?
Hop2 Out.mov
Is this rappleing?
Flap Across.mov
</Test>
<Train>
She is going to rapple the room.
Hop2 In.mov
She is going to rapple the stairs.
Hop2 Up.mov
He is going to rapple the table.
Hop2 Along.mov
She is going to rapple the lounge.
Hop2 Turn.mov
She is going rapple the ramp.
Hop2 Down.mov
</Train>
<Test>
Is this rappleing?
Stoop Across.mov
Is this rappleing?
Hop2 Front.mov
</Test>
<Train>
She is going to bamp the chairs.
Crawl Between.mov
</Train>
<Test>
Is this bamping?
Stoop Between.mov
Is this bamping?
Crawl Around.mov
</Test>
<Train>
She is going to bamp the hill.
Crawl Up.mov
She is going to bamp the chair.
Crawl Behind.mov
She is going to bamp the hall.
Crawl Turn.mov
She is going to bamp the museaum.
Crawl In2.mov
She is going to bamp the stone.
Crawl Over.mov
</Train>
<Test>
Is this bamping?
Crawl Along.mov
Is this bamping?
Tiptoe Between.mov
</Test>
<Train>
She is going to minje the bench.
Dance Over.mov
</Train>
<Test>
Is this minjing?
Dance In.mov
Is this minjing?
Hop2 Over.mov
</Test>
<Train>
She is going to minje the path.
Dance Across.mov
She is going to minje the stairs.
Dance Down.mov
She is going to minje the TV.
Dance Front.mov
She is going to minje the garden.
Dance Out.mov
She is going to minje the tree.
Dance Around.mov
</Train>
<Test>
Is this minjing?
March Over.mov
Is this minjing?
Dance Along.mov
</Test>
<Train>
She is going to morp the kitchen.
Crab Out.mov
</Train>
<Test>
Is this morping?
Crab Behind.mov
Is this morping?
Run Out.mov
</Test>
<Train>
She is going to morp chair.
Crab Front.mov
She is going to morp the door.
Crab In.mov
She is going to morp the chairs.
Crab Between.mov
She is going to morp the path.
Crab Across.mov
She is going to morp the hall.
Crab Turn.mov
</Train>
<Test>
Is this morping?
March Out.mov
Is this morping?
Crab Along.mov
</Test>
<Train>
She is going to torg the slide.
Flap Up.mov
</Train>
<Test>
Is this torging?

Walk Up.mov
Is this torging?
Flap Between.mov
</Test>
<Train>
She is going to torg the ramp.
Flap Down.mov
She is going to torg the lamp post.
Flap Around.mov
She is going to torg the building.
Flap In.mov
She is going to torg the picnic table.
Flap Front.mov
She is going to torg the barrier.
Flap Over.mov
</Train>
<Test>
Is this torging?
Flap Turn.mov
Is this torging?
Hop2 Up.mov
</Test>
<Train>
She is going to floop the TV.
Tiptoe Front.mov
</Train>
<Test>
Is this flooping?
Tiptoe Turn.mov
Is this flooping?
March Front.mov
</Test>
<Train>
She is going to floop the bush.
Tiptoe Around.mov
She is going to floop the green bench.
Tiptoe Over.mov
She is going to floop the house.
Tiptoe In.mov
She is going to floop the stairs.
Tiptoe Up.mov
She is going to floop the door.
Tiptoe Out.mov
</Train>
<Test>
Is this flooping?
Stoop Front.mov
Is this flooping?
Tiptoe Down.mov
</Test>
<Train>
She is going to plamp the hedge.
Hop1 Along.mov
</Train>
<Test>
Is this plamping?
Hop1 Around.mov
Is this plamping?
Flap Along.mov
</Test>
<Train>
He is going to plamp the room.
Hop1 Out.mov
She is going to plamp the hall.
Hop1 Across.mov
She is going to plamp the cars.
Hop1 Between.mov
She is going to plamp the ramp.
Hop1 Up.mov
She is going to plamp the door.
Hop1 In.mov
</Train>
<Test>
Is this plamping?
Stoop Along.mov
Is this plamping?
Hop1 Over.mov
</Test>
<Train>
She is going to gleck the lounge.
March Turn.mov
</Train>
<Test>
Is this glecking?
Run Turn.mov
Is this glecking?
March Up.mov
</Test>
<Train>
He is going to gleck the chair.
March Behind.mov
She is going to gleck the door.
March Out.mov
She is going to gleck the road.
March Across.mov
She is going to gleck the chair.
March Around.mov
She is going to gleck the garbage cans.
March Between.mov
</Train>
<Test>
Is this glecking?
Dance Turn.mov
Is this glecking?
March Down.mov
</Test>
<Train>
She is going to birk the garden.
Skip In.mov
</Train>
<Test>
Is this birking?
Skip Front.mov
Is this birking?
Stoop In.mov
</Test>
<Train>
She is going to birk the cars.
Skip Between.mov
She is going to birk the hill.
Skip Up.mov
She is going to birk the room.

Skip Out.mov
She is going to birk the wall.
Skip Along.mov
He is going to birk the path.
Skip Across.mov
</Train>
<Test>
Is this birking?
Crawl In.mov
Is this birking?
Skip Over.mov
</Test>
<Train>
She is going to molk the chair.
Walk Around.mov
</Train>
<Test>
Is this molking?
Walk Down.mov
Is this molking?
Run Around.mov
</Test>
<Train>
She is going to molk the picnic table.
Walk Over.mov
She is going to molk the garden.
Walk Turn.mov
She is going to molk the green chair.
Walk Front.mov
She is going to molk the chairs.
Walk Between.mov
She is going to molk the magnifying glass.
Walk Behind.mov
</Train>
<Test>
Is this molking?
Walk Out.mov
Is this molking?
Crab Around.mov
</Test>
<Train>
She is going to belf the hill.
Stoop Down.mov
</Train>
<Test>
Is this belfing?
Crawl Down.mov
Is this belfing?
Stoop Around.mov
</Test>
<Train>
She is going to belf the lawn.
Stoop Turn.mov
He is going to belf the hallway.
Stoop Over.mov
He is going to belf the TV.
Stoop Behind.mov
She is going to belf the building.
Stoop Out.mov
She is going to belf the hall.
Stoop In2.mov
</Train>
<Test>
Is this belfing?
Stoop Up.mov
Is this belfing?
Hop1 Down.mov
</Test>
<Train>
She is going to freen the sign.
Run Behind.mov
</Train>
<Test>
Is this freening?
Tiptoe Behind.mov
Is this freening?
Run Along.mov
</Test>
<Train>
She is going to freen the telephone books.
Run Over.mov
She is going to freen the desk.
Run Front.mov
She is going to freen the tree.
Run Around.mov
She is going to freen the church.
Run In.mov
He is going to freen the ramp.
Run Down.mov
</Train>
<Test>
Is this freening?
Run Across.mov
Is this freening?
Dance Behind.mov
</Test>

C.2.2 Poor Frame 25% Path

<Train>
She is going rapple the path.
Hop2 Across.mov
</Train>
<Test>
Is this rappleing?
Hop2 Out.mov
Is this rappleing?
Flap Across.mov
</Test>
<Train>
She is going to rapple the room.
Hop2 In.mov
She is going to rapple the stairs.
Hop2 Up.mov
He is going to rapple the table.
Hop2 Along.mov
She is going to rapple the lounge.
Hop2 Turn.mov
She is going rapple the ramp.
Hop2 Down.mov
</Train>
<Test>
Is this rappleing?
Stoop Across.mov
Is this rappleing?
Hop2 Front.mov
</Test>
<Train>
She is going to bamp the chairs.
Crawl Between.mov
</Train>
<Test>
Is this bamping?
Stoop Between.mov
Is this bamping?
Crawl Around.mov
</Test>
<Train>
She is going to bamp the cars.
Skip Between.mov
She is going to bamp the garbage cans.
March Between.mov
She is going to bamp the chairs.
Crab Between.mov
She is going to bamp the chairs.
Walk Between.mov
She is going to bamp the cars.
Hop1 Between.mov
</Train>
<Test>
Is this bamping?
Crawl Along.mov
Is this bamping?
Tiptoe Between.mov
</Test>
<Train>
She is going to minje the bench.
Dance Over.mov
</Train>
<Test>
Is this minjing?
Dance In.mov
Is this minjing?
Hop2 Over.mov
</Test>
<Train>
She is going to minje the path.
Dance Across.mov
She is going to minje the stairs.
Dance Down.mov
She is going to minje the TV.
Dance Front.mov
She is going to minje the garden.
Dance Out.mov
She is going to minje the tree.
Dance Around.mov
</Train>
<Test>
Is this minjing?
March Over.mov
Is this minjing?
Dance Along.mov
</Test>
<Train>
She is going to morp the kitchen.
Crab Out.mov
</Train>
<Test>
Is this morping?
Crab Behind.mov
Is this morping?
Run Out.mov
</Test>
<Train>
She is going to morp the chair.
Crab Front.mov
She is going to morp the door.
Crab In.mov
She is going to morp the chairs.
Crab Between.mov
She is going to morp the path.
Crab Across.mov
She is going to morp the hall.
Crab Turn.mov
</Train>
<Test>
Is this morping?
March Out.mov
Is this morping?
Crab Along.mov
</Test>
<Train>
She is going to torg the slide.
Flap Up.mov
</Train>
<Test>
Is this torging?
Walk Up.mov
Is this torging?
Flap Between.mov

</Test>
<Train>
She is going to torg the ramp.
Flap Down.mov
She is going to torg the lamp post.
Flap Around.mov
She is going to torg the building.
Flap In.mov
She is going to torg the picnic table.
Flap Front.mov
She is going to torg the barrier.
Flap Over.mov
</Train>
<Test>
Is this torging?
Flap Turn.mov
Is this torging?
Hop2 Up.mov
</Test>
<Train>
She is going to floop the TV.
Tiptoe Front.mov
</Train>
<Test>
Is this flooping?
Tiptoe Turn.mov
Is this flooping?
March Front.mov
</Test>
<Train>
She is going to floop the bush.
Tiptoe Around.mov
She is going to floop the green bench.
Tiptoe Over.mov
She is going to floop the house.
Tiptoe In.mov
She is going to floop the stairs.
Tiptoe Up.mov
She is going to floop the door.
Tiptoe Out.mov
</Train>
<Test>
Is this flooping?
Stoop Front.mov
Is this flooping?
Tiptoe Down.mov
</Test>
<Train>
She is going to plamp the hedge.
Hop1 Along.mov
</Train>
<Test>
Is this plamping?
Hop1 Around.mov
Is this plamping?
Flap Along.mov
</Test>
<Train>
He is going to plamp the table.
Hop2 Along.mov
She is going to plamp the hedge.
Walk Along2.mov
She is going to plamp the chalk board.
Run Along.mov
She is going to plamp the hedge.
Skip Along2.mov
She is going to plamp the stone wall.
Walk Along.mov
</Train>
<Test>
Is this plamping?
Stoop Along.mov
Is this plamping?
Hop1 Over.mov
</Test>
<Train>
She is going to gleck the lounge.
March Turn.mov
</Train>
<Test>
Is this glecking?
Run Turn.mov
Is this glecking?
March Up.mov
</Test>
<Train>
He is going to gleck the chair.
March Behind.mov
She is going to gleck the door.
March Out.mov
She is going to gleck the road.
March Across.mov
She is going to gleck the chair.
March Around.mov
She is going to gleck the garbage cans.
March Between.mov
</Train>
<Test>
Is this glecking?
Dance Turn.mov
Is this glecking?
March Down.mov
</Test>
<Train>
She is going to birk the garden.
Skip In.mov
</Train>
<Test>
Is this birking?
Skip Front.mov
Is this birking?
Stoop In.mov
</Test>
<Train>
She is going to birk the cars.
Skip Between.mov
She is going to birk the hill.
Skip Up.mov
She is going to birk the room.
Skip Out.mov
She is going to birk the wall.
Skip Along.mov

He is going to birk the path.
Skip Across.mov
</Train>
<Test>
Is this birking?
Crawl In.mov
Is this birking?
Skip Over.mov
</Test>
<Train>
She is going to molk the chair.
Walk Around.mov
</Train>
<Test>
Is this molking?
Walk Down.mov
Is this molking?
Run Around.mov
</Test>
<Train>
She is going to molk the tree.
Dance Around.mov
She is going to molk the bush.
Tiptoe Around.mov
She is going to molk the oak.
Hop2 Around.mov
She is going to molk the chair.
March Around.mov
She is going to molk the lamp post.
Flap Around.mov
</Train>
<Test>
Is this molking?
Walk Out.mov
Is this molking?
Crab Around.mov
</Test>
<Train>
She is going to belf the hill.
Stoop Down.mov
</Train>
<Test>
Is this belfing?
Crawl Down.mov
Is this belfing?
Stoop Around.mov
</Test>
<Train>
She is going to belf the lawn.
Stoop Turn.mov
He is going to belf the hallway.
Stoop Over.mov
He is going to belf the TV.
Stoop Behind.mov
She is going to belf the building.
Stoop Out.mov
She is going to belf the hall.
Stoop In2.mov
</Train>
<Test>
Is this belfing?
Stoop Up.mov
Is this belfing?
Hop1 Down.mov
</Test>
<Train>
She is going to freen the sign.
Run Behind.mov
</Train>
<Test>
Is this freening?
Tiptoe Behind.mov
Is this freening?
Run Along.mov
</Test>
<Train>
She is going to freen the telephone books.
Run Over.mov
She is going to freen the desk.
Run Front.mov
She is going to freen the tree.
Run Around.mov
She is going to freen the church.
Run In.mov
He is going to freen the ramp.
Run Down.mov
</Train>
<Test>
Is this freening?
Run Across.mov
Is this freening?
Dance Behind.mov
</Test>

C.2.3 Poor Frame 50% Path

<Train>
She is going to rapple the path.
Hop2 Across.mov
</Train>
<Test>
Is this rappling?
Hop2 Out.mov
Is this rappling?
Flap Across.mov
</Test>
<Train>
She is going to rapple the hall.
Hop1 Across.mov
She is going to rapple the path.
Stoop Across.mov
She is going to rapple the path.
Dance Across.mov
She is going to rapple the sand box.
Walk Across.mov
She is going to rapple the path.
Skip Across.mov
</Train>
<Test>
Is this rappling?
Crab Across.mov
Is this rappling?
Hop2 Front.mov
</Test>
<Train>
She is going to bamp the chairs.
Crawl Between.mov
</Train>
<Test>
Is this bamping?
Stoop Between.mov
Is this bamping?
Crawl Around.mov
</Test>
<Train>
She is going to bamp the hill.
Crawl Up.mov
She is going to bamp the chair.
Crawl Behind.mov
She is going to bamp the hall.
Crawl Turn.mov
She is going to bamp the museum.
Crawl In2.mov
She is going to bamp the stone.
Crawl Over.mov
</Train>
<Test>
Is this bamping?
Crawl Along.mov
Is this bamping?
Tiptoe Between.mov
</Test>
<Train>
She is going to minje the bench.
Dance Over.mov
</Train>
<Test>
Is this minjing?
Dance In.mov
Is this minjing?
Hop2 Over.mov
</Test>
<Train>
She is going to minje the path.
Dance Across.mov
She is going to minje the stairs.
Dance Down.mov
She is going to minje the TV.
Dance Front.mov
He is going to minje the garden.
Dance Out.mov
She is going to minje the tree.
Dance Around.mov
</Train>
<Test>
Is this minjing?
March Over.mov
Is this minjing?
Dance Along.mov
</Test>
<Train>
She is going to morp the kitchen.
Crab Out.mov
</Train>
<Test>
Is this morping?
Crab Behind.mov
Is this morping?
Run Out.mov
</Test>
<Train>
He is going to morp the room.
Hop1 Out.mov
She is going to morp the gate.
Dance Out.mov
She is going to morp the lab.
Walk Out.mov
She is going to morp the hall.
Skip Out.mov
She is going to morp the building.
Stoop Out.mov
</Train>
<Test>
Is this morping?
March Out.mov
Is this morping?
Crab Along.mov
</Test>
<Train>
She is going to torg the slide.
Flap Up.mov
</Train>
<Test>
Is this torging?
Walk Up.mov
Is this torging?
Flap Between.mov

</Test>
<Train>
She is going to torg the ramp.
Flap Down.mov
She is going to torg the lamp post.
Flap Around.mov
She is going to torg the building.
Flap In.mov
She is going to torg the picnic table.
Flap Front.mov
She is going to torg the barier.
Flap Over.mov
</Train>
<Test>
Is this torging?
Flap Turn.mov
Is this torging?
Hop2 Up.mov
</Test>
<Train>
She is going to floop the TV.
Tiptoe Front.mov
</Train>
<Test>
Is this flooping?
Tiptoe Turn.mov
Is this flooping?
March Front.mov
</Test>
<Train>
She is going to floop the bush.
Tiptoe Around.mov
She is going to floop the green bench.
Tiptoe Over.mov
She is going to floop the house.
Tiptoe In.mov
She is going to floop the stairs.
Tiptoe Up.mov
She is going to floop the door.
Tiptoe Out.mov
</Train>
<Test>
Is this flooping?
Stoop Front.mov
Is this flooping?
Tiptoe Down.mov
</Test>
<Train>
She is going to plamp the hedge.
Hop1 Along.mov
</Train>
<Test>
Is this plamping?
Hop1 Around.mov
Is this plamping?
Flap Along.mov
</Test>
<Train>
She is going to plamp the stone wall.
Dance Along.mov
She is going to plamp the wall.
Skip Along.mov
She is going to plamp the hedge.
Walk Along2.mov
She is going to plamp the blackboard.
Run Along.mov
She is going to plamp the stone wall.
Walk Along.mov
</Train>
<Test>
Is this plamping?
Stoop Along.mov
Is this plamping?
Hop1 Over.mov
</Test>
<Train>
She is going to gleck the lounge.
March Turn.mov
</Train>
<Test>
Is this glecking?
Run Turn.mov
Is this glecking?
March Up.mov
</Test>
<Train>
He is going to gleck the chair.
March Behind.mov
She is going to gleck the door.
March Out.mov
She is going to gleck the road.
March Across.mov
She is going to gleck the chair.
March Around.mov
She is going to gleck the garbage cans.
March Between.mov
</Train>
<Test>
Is this glecking?
Dance Turn.mov
Is this glecking?
March Down.mov
</Test>
<Train>
She is going to birk the garden.
Skip In.mov
</Train>
<Test>
Is this birking?
Skip Front.mov
Is this birking?
Stoop In.mov
</Test>
<Train>
She is going to birk the cars.
Skip Between.mov
She is going to birk the hill.
Skip Up.mov
She is going to birk the room.
Skip Out.mov
She is going to birk the wall.
Skip Along.mov

He is going to birk the path.
Skip Across.mov
</Train>
<Test>
Is this birking?
Crawl In.mov
Is this birking?
Skip Over.mov
</Test>
<Train>
She is going to molk the chair.
Walk Around.mov
</Train>
<Test>
Is this molking?
Walk Down.mov
Is this molking?
Run Around.mov
</Test>
<Train>
She is going to molk the tree.
Dance Around.mov
She is going to molk the bush.
Tiptoe Around.mov
She is going to molk the oak.
Hop2 Around.mov
She is going to molk the chair.
March Around.mov
She is going to molk the lamp post.
Flap Around.mov
</Train>
<Test>
Is this molking?
Walk Out.mov
Is this molking?
Crab Around.mov
</Test>
<Train>
She is going to belf the hill.
Stoop Down.mov
</Train>
<Test>
Is this belfing?
Crawl Down.mov
Is this belfing?
Stoop Around.mov
</Test>
<Train>
She is going to belf the slide.
Tiptoe Down.mov
She is going to belf the ramp.
Crawl Down.mov
She is going to belf the stairs.
Dance Down.mov
She is going to belf the hill.
Crab Down.mov
He is going to belf the stairs.
Walk Down.mov
</Train>
<Test>
Is this belfing?
Stoop Up.mov
Is this belfing?
Hop1 Down.mov
</Test>
<Train>
She is going to freen the sign.
Run Behind.mov
</Train>
<Test>
Is this freening?
Tiptoe Behind.mov
Is this freening?
Run Along.mov
</Test>
<Train>
She is going to freen the cart.
Hop1 Behind.mov
He is going to freen the chair
March Behind.mov
She is going to freen the sign board.
Crab Behind.mov
He is going to freen the garbage can.
Dance Behind.mov
He is going to freen the chair.
Skip Behind.mov
</Train>
<Test>
Is this freening?
Run Across.mov
Is this freening?
Stoop Behind.mov
</Test>

C.2.4 Poor Frame 75% Path

<Train>
She is going to rapple the path.
Hop2 Across.mov
</Train>
<Test>
Is this rappleing?
Hop2 Out.mov
Is this rappleing?
Flap Across.mov
</Test>
<Train>
She is going to rapple the sand box.
Walk Across.mov
She is going to rapple the path.
Dance Across.mov
She is going to rapple the path.
Crab Across.mov
He is going to rapple the sidewalk.
Skip Across.mov
She is going to rapple the hall.
Hop1 Across.mov
</Train>
<Test>
Is this rappleing?
Stoop Across.mov
Is this rappleing?
Hop2 Front.mov
</Test>
<Train>
She is going to bamp the chairs.
Crawl Between.mov
</Train>
<Test>
Is this bamping?
Stoop Between.mov
Is this bamping?
Crawl Around.mov
</Test>
<Train>
She is going to bamp the cars.
Skip Between.mov
She is going to bamp the garbage cans.
March Between.mov
She is going to bamp the chairs.
Crab Between.mov
She is going to bamp the chairs.
Walk Between.mov
She is going to bamp the cars.
Hop1 Between.mov
</Train>
<Test>
Is this bamping?
Crawl Along.mov
Is this bamping?
Tiptoe Between.mov
</Test>
<Train>
She is going to minje the bench.
Dance Over.mov
</Train>
<Test>
Is this minjing?
Dance In.mov
Is this minjing?
Hop2 Over.mov
</Test>
<Train>
She is going to minje the phone books.
Run Over.mov
She is going to minje the bench.
Tiptoe Over.mov
She is going to minje the barrier.
Flap Over.mov
She is going to minje a rock.
Crawl Over.mov
She is going to minje the picnic table.
Walk Over.mov
</Train>
<Test>
Is this minjing?
March Over.mov
Is this minjing?
Dance Along.mov
</Test>
<Train>
She is going to morp the kitchen.
Crab Out.mov
</Train>
<Test>
Is this morping?
Crab Behind.mov
Is this morping?
Run Out.mov
</Test>
<Train>
He is going to morp the room.
Hop1 Out.mov
She is going to morp the lab.
Tiptoe Out.mov
She is going to morp the hall.
Skip Out.mov
She is going to morp the building.
Stoop Out.mov
She is going to morp the garden.
Dance Out.mov
</Train>
<Test>
Is this morping?
March Out.mov
Is this morping?
Crab Along.mov
</Test>
<Train>
She is going to torg the slide.
Flap Up.mov
</Train>
<Test>
Is this torging?
Walk Up.mov
Is this torging?
Flap Between.mov

</Test>
<Train>
She is going to torg the stairs.
Tiptoe Up.mov
She is going to torg the hill.
Skip Up.mov
She is going to torg the steps.
Crawl Up2.mov
She is going to torg the ramp.
Hop1 Up.mov
She is going torg the hill.
Crawl Up.mov
</Train>
<Test>
Is this torging?
Flap Turn.mov
Is this torging?
Hop2 Up.mov
</Test>
<Train>
She is going to floop the TV cart.
Tiptoe Front.mov
</Train>
<Test>
Is this flooping?
Tiptoe Turn.mov
Is this flooping?
March Front.mov
</Test>
<Train>
She is going to floop the green chair.
Walk Front.mov
She is going to floop the picnic table.
Flap Front.mov
She is going to floop the TV cart.
Dance Front.mov
She is going to floop the desk.
Run Front.mov
She is going to floop the sign.
Crab Front.mov
</Train>
<Test>
Is this flooping?
Stoop Front.mov
Is this flooping?
Tiptoe Down.mov
</Test>
<Train>
She is going to plamp the hedge.
Hop1 Along.mov
</Train>
<Test>
Is this plamping?
Hop1 Around.mov
Is this plamping?
Flap Along.mov
</Test>
<Train>
He is going to plamp the table.
Hop2 Along.mov
She is going to plamp the hedge.
Walk Along2.mov
She is going to plamp the chalk board.
Run Along.mov
She is going to plamp the hedge.
Skip Along2.mov
She is going to plamp the stone wall.
Walk Along.mov
</Train>
<Test>
Is this plamping?
Stoop Along.mov
Is this plamping?
Hop1 Over.mov
</Test>
<Train>
She is going to gleck the lounge.
March Turn.mov
</Train>
<Test>
Is this glecking?
Run Turn.mov
Is this glecking?
March Up.mov
</Test>
<Train>
She is going to gleck the grass.
Stoop Turn.mov
She is going to gleck the hallway.
Crawl Turn.mov
She is going to gleck the garden.
Hop1 Turn.mov
She is going to gleck the garden.
Walk Turn.mov
She is going to gleck the lounge.
Hop2 Turn.mov
</Train>
<Test>
Is this glecking?
Dance Turn.mov
Is this glecking?
March Down.mov
</Test>
<Train>
She is going to birk the garden.
Skip In.mov
</Train>
<Test>
Is this birking?
Skip Front.mov
Is this birking?
Stoop In.mov
</Test>
<Train>
She is going to birk the church.
Flap In.mov
She is going to birk the lab.
Hop2 In.mov
She is going to birk the house.
Tiptoe In.mov
She is going to birk the church.
Run In.mov

She is going to birk the museum.
Hop1 In.mov
</Train>
<Test>
Is this birking?
Crawl In.mov
Is this birking?
Skip Over.mov
</Test>
<Train>
She is going to molk the chair.
Walk Around.mov
</Train>
<Test>
Is this molking?
Walk Down.mov
Is this molking?
Run Around.mov
</Test>
<Train>
She is going to molk the tree.
Dance Around.mov
She is going to molk the bush.
Tiptoe Around.mov
She is going to molk the oak.
Hop2 Around.mov
She is going to molk the chair.
March Around.mov
She is going to molk the lamp post.
Flap Around.mov
</Train>
<Test>
Is this molking?
Walk Out.mov
Is this molking?
Crab Around.mov
</Test>
<Train>
She is going to belf the hill.
Stoop Down.mov
</Train>
<Test>
Is this belfing?
Crawl Down.mov
Is this belfing?
Stoop Around.mov
</Test>
<Train>
She is going to belf the ramp.
Flap Down.mov
She is going to belf the ramp.
March Down.mov
She is going to belf the stairs.
Dance Down.mov
She is going to belf the ramp.
Hop2 Down.mov
She is going to belf the hill.
Crab Down.mov
</Train>
<Test>
Is this belfing?
Stoop Up.mov
Is this belfing?
Hop1 Down.mov
</Test>
<Train>
She is going to freen the sign.
Run Behind.mov
</Train>
<Test>
Is this freening?
Tiptoe Behind.mov
Is this freening?
Run Along.mov
</Test>
<Train>
He is going to freen the chair.
Skip Behind.mov
She is going to freen the cart.
Hop1 Behind.mov
She is going to freen the chair.
Crawl Behind.mov
She is going to freen the TV.
Stoop Behind.mov
He is going to freen the chair.
March Behind.mov
</Train>
<Test>
Is this freening?
Run Across.mov
Is this freening?
Dance Behind.mov
</Test>

C.2.5 Poor Frame 100% Path

<Train>
She is going to rapple the path.
Hop2 Across.mov
</Train>
<Test>
Is this rappleing?
Hop2 Out.mov
Is this rappleing?
Flap Across.mov
</Test>
<Train>
She is going to rapple the sand box.
Walk Across.mov
She is going to rapple the path.
Dance Across.mov
She is going to rapple the path.
Crab Across.mov
He is going to rapple the sidewalk.
Skip Across.mov
She is going to rapple the hall.
Hop1 Across.mov
</Train>
<Test>
Is this rappleing?
Stoop Across.mov
Is this rappleing?
Hop2 Front.mov
</Test>
<Train>
She is going to bamp the chairs.
Crawl Between.mov
</Train>
<Test>
Is this bamping?
Stoop Between.mov
Is this bamping?
Crawl Around.mov
</Test>
<Train>
She is going to bamp the cars.
Skip Between.mov
She is going to bamp the garbage cans.
March Between.mov
She is going to bamp the chairs.
Crab Between.mov
She is going to bamp the chairs.
Walk Between.mov
She is going to bamp the cars.
Hop1 Between.mov
</Train>
<Test>
Is this bamping?
Crawl Along.mov
Is this bamping?
Tiptoe Between.mov
</Test>
<Train>
She is going to minje the bench.
Dance Over.mov
</Train>
<Test>
Is this minjing?
Dance In.mov
Is this minjing?
Hop2 Over.mov
</Test>
<Train>
She is going to minje the phone books.
Run Over.mov
She is going to minje the bench.
Tiptoe Over.mov
She is going to minje the barrier.
Flap Over.mov
She is going to minje a rock.
Crawl Over.mov
She is going to minje the picnic table.
Walk Over.mov
</Train>
<Test>
Is this minjing?
March Over.mov
Is this minjing?
Dance Along.mov
</Test>
<Train>
She is going to morp the kitchen.
Crab Out.mov
</Train>
<Test>
Is this morping?
Crab Behind.mov
Is this morping?
Run Out.mov
</Test>
<Train>
He is going to morp the room.
Hop1 Out.mov
She is going to morp the lab.
Tiptoe Out.mov
She is going to morp the hall.
Skip Out.mov
She is going to morp the building.
Stoop Out.mov
She is going to morp the garden.
Dance Out.mov
</Train>
<Test>
Is this morping?
March Out.mov
Is this morping?
Crab Along.mov
</Test>
<Train>
She is going to torg the slide.
Flap Up.mov
</Train>
<Test>
Is this torging?
Walk Up.mov
Is this torging?
Flap Between.mov

</Test>
<Train>
She is going to torg the stairs.
Tiptoe Up.mov
She is going to torg the hill.
Skip Up.mov
She is going to torg the steps.
Crawl Up2.mov
She is going to torg the ramp.
Hop1 Up.mov
She is going torg the hill.
Crawl Up.mov
</Train>
<Test>
Is this torging?
Flap Turn.mov
Is this torging?
Hop2 Up.mov
</Test>
<Train>
She is going to floop the TV cart.
Tiptoe Front.mov
</Train>
<Test>
Is this flooping?
Tiptoe Turn.mov
Is this flooping?
March Front.mov
</Test>
<Train>
She is going to floop the green chair.
Walk Front.mov
She is going to floop the picnic table.
Flap Front.mov
She is going to floop the TV cart.
Dance Front.mov
She is going to floop the desk.
Run Front.mov
She is going to floop the sign.
Crab Front.mov
</Train>
<Test>
Is this flooping?
Stoop Front.mov
Is this flooping?
Tiptoe Down.mov
</Test>
<Train>
She is going to plamp the hedge.
Hop1 Along.mov
</Train>
<Test>
Is this plamping?
Hop1 Around.mov
Is this plamping?
Flap Along.mov
</Test>
<Train>
He is going to plamp the table.
Hop2 Along.mov
She is going to plamp the hedge.
Walk Along2.mov
She is going to plamp the chalk board.
Run Along.mov
She is going to plamp the hedge.
Skip Along2.mov
She is going to plamp the stone wall.
Walk Along.mov
</Train>
<Test>
Is this plamping?
Stoop Along.mov
Is this plamping?
Hop1 Over.mov
</Test>
<Train>
She is going to gleck the lounge.
March Turn.mov
</Train>
<Test>
Is this glecking?
Run Turn.mov
Is this glecking?
March Up.mov
</Test>
<Train>
She is going to gleck the grass.
Stoop Turn.mov
She is going to gleck the hallway.
Crawl Turn.mov
She is going to gleck the garden.
Hop1 Turn.mov
She is going to gleck the garden.
Walk Turn.mov
She is going to gleck the lounge.
Hop2 Turn.mov
</Train>
<Test>
Is this glecking?
Dance Turn.mov
Is this glecking?
March Down.mov
</Test>
<Train>
She is going to birk the garden.
Skip In.mov
</Train>
<Test>
Is this birking?
Skip Front.mov
Is this birking?
Stoop In.mov
</Test>
<Train>
She is going to birk the church.
Flap In.mov
She is going to birk the lab.
Hop2 In.mov
She is going to birk the house.
Tiptoe In.mov
She is going to birk the church.
Run In.mov

She is going to birk the museum.
Hop1 In.mov
</Train>
<Test>
Is this birking?
Crawl In.mov
Is this birking?
Skip Over.mov
</Test>
<Train>
She is going to molk the chair.
Walk Around.mov
</Train>
<Test>
Is this molking?
Walk Down.mov
Is this molking?
Run Around.mov
</Test>
<Train>
She is going to molk the tree.
Dance Around.mov
She is going to molk the bush.
Tiptoe Around.mov
She is going to molk the oak.
Hop2 Around.mov
She is going to molk the chair.
March Around.mov
She is going to molk the lamp post.
Flap Around.mov
</Train>
<Test>
Is this molking?
Walk Out.mov
Is this molking?
Crab Around.mov
</Test>
<Train>
She is going to belf the hill.
Stoop Down.mov
</Train>
<Test>
Is this belfing?
Crawl Down.mov
Is this belfing?
Stoop Around.mov
</Test>
<Train>
She is going to belf the ramp.
Flap Down.mov
She is going to belf the ramp.
March Down.mov
She is going to belf the stairs.
Dance Down.mov
She is going to belf the ramp.
Hop2 Down.mov
She is going to belf the hill.
Crab Down.mov
</Train>
<Test>
Is this belfing?
Stoop Up.mov
Is this belfing?
Hop1 Down.mov
</Test>
<Train>
She is going to freen the sign.
Run Behind.mov
</Train>
<Test>
Is this freening?
Tiptoe Behind.mov
Is this freening?
Run Along.mov
</Test>
<Train>
He is going to freen the chair.
Skip Behind.mov
She is going to freen the cart.
Hop1 Behind.mov
She is going to freen the chair.
Crawl Behind.mov
She is going to freen the TV.
Stoop Behind.mov
He is going to freen the chair.
March Behind.mov
</Train>
<Test>
Is this freening?
Run Across.mov
Is this freening?
Dance Behind.mov
</Test>

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