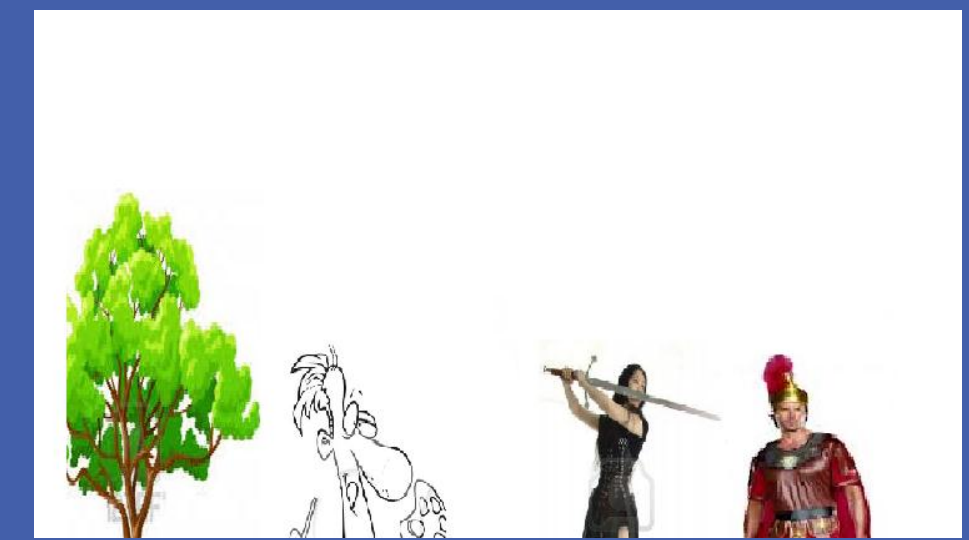# Study of structure disambiguation using eye tracking
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Introduction

Many studies have been done to understand the interplay of utterance and visual cues in comprehension, disambiguation of the sentence structure and thematic role assignment. An interesting experiment done by Tanenhause at el. used ambiguous instructions such as *"Put the apple on the towel in the box"* the phrase "on the towel" is a modifier of the noun phrase. However, it can also be viewed temporarily as a modifier of the verb and can be used to identify the destination of the apple as the towel. When the sentence was uttered and an image of an apple kept on a towel and an empty towel was shown to the subject, the subject initially looked the apple, but fixated immediately on the empty towel on comprehending the phrase, "on the towel" as the destination instead of a noun phrase modifier. However, when the subject was shown two apples one of which was kept on a towel and the other one on the table, the subject's gaze kept oscillating between the two apples while listening to the noun phrase before fixating on the apple on the towel while listening to the noun phrase modifier.

Through this project I wish to observe and make plots of proportion of eye gaze with respect to time for ambiguous sentences in Hindi

Objectives

Through above mentioned studies it was found that the subjects use utterances, visual clues and their worldly knowledge to disambiguate the sentence structure. The objective of this project is to observe and study if the attention to the scene is closely time- bound to the utterance and disambiguation. Knoeferle et al have done such experiments in English and German, however no such study has been done in Hindi. In this project I have used the following sentences:

राजकुमारी ने सेनापति को तलवार से मारा I (1)

राजकुमारी ने चित्रकार से चित्र बनवाते हुए सेनापति को तलवार से मारा I (2)

In the first sentence there is no ambiguity, and the second sentence shows structural ambiguity since the thematic role of "राजकुमारी" is ambiguous. "राजकुमारी" is ambiguous because she is the agent in the phrase "राजकुमारी ने सेनापति को तलवार से मारा" where "सेनापति" is the patient. However, in the phrase "राजकुमारी ने चित्रकार से चित्र बनवाते हुए", "राजकुमारी" acts like a patient and "चित्रकार" is the second patient.

Method

The study was done on five subjects using four ambiguous sentences and two scenes each. The subject was shown an image while the sentences were uttered. The gaze parameters of the subject were recorded using BeGaze 3.2.28 analysis software. The raw data from each subject included the gaze positions in x-y coordinates with respect to time. The positions of characters on screen were approximated as rectangles and the gaze coordinates were compared to the boundaries of rectangles enclosing the characters on screen. Whenever the gaze was inside the rectangle of a character, a value corresponding to the character was assigned to that point of time. A one dim. matrix was formed with values 1, 2 or 3 for the three different characters on the screen. To calculate gaze proportion for each character at an interval of 100 data points, the number of 1's, 2's and3's in the matrix were counted using a function and the count was divided by 100 to get the gaze proportion for the three characters. 10 such intervals were used to cover the entire data set for one subject. The proportion was then plotted against 10 points on time axis to get the final plots.

The function used for calculation of gaze is shown:

```
function z = plotg (Y,X,t)

counth=0;
counto=0;
countt=0;
for i=1:length(X)
    if ((X(i)<200)&&(X(i)>100)&&(Y(i)<200)&&(Y(i)>100))
        time(i)=1
    elseif ((X(i)<300)&&(X(i)>200)&&(Y(i)<300)&&(Y(i)>200))
        time(i)=2
    elseif ((X(i)<600)&&(X(i)>500)&&(Y(i)<600)&&(Y(i)>500))
        time(i)=3
    else
        time(i) = 4
    end
end

for j=1:100:length(t)-100
    for k=j:j+100

        if(time(k)==1)
            counto=counto+1;
        elseif(time(k)==2)
            countt=countt+1;
        elseif(time(k)==3)
            counth=counth+1;
        end
    end
    prop(1,j)=counto/100;
    prop(2,j)=countt/100;
    prop(3,j)=counth/100;

end
```

Results

From the plotted graphs, it is evident that the subjects fixate in high proportions at the ambiguous character in the beginning of the sentence. Initially the proportion is greater for the first sentence than second. However, unlike second sentence the gaze proportion falls down rapidly with time for the first sentence. This is because in second sentence राजकुमारी is the patient of verb "बनवाते हुए". It has been observed through the graphs obtained, that the subject tries to predict the patient when he hears the verb. This explains more gaze proportion for ambiguous character in second sentence. For the graph of patient and agent it has been observed that the gaze proportion to the patient is more than that of agent in both the sentences. When the subject hears the phrase "राजकुमारी ने", he looks for the patient of the verb. However when the subject hears the phrase "चित्रकार से चित्र बनवाते हुए" he does not fixate much on the patient.
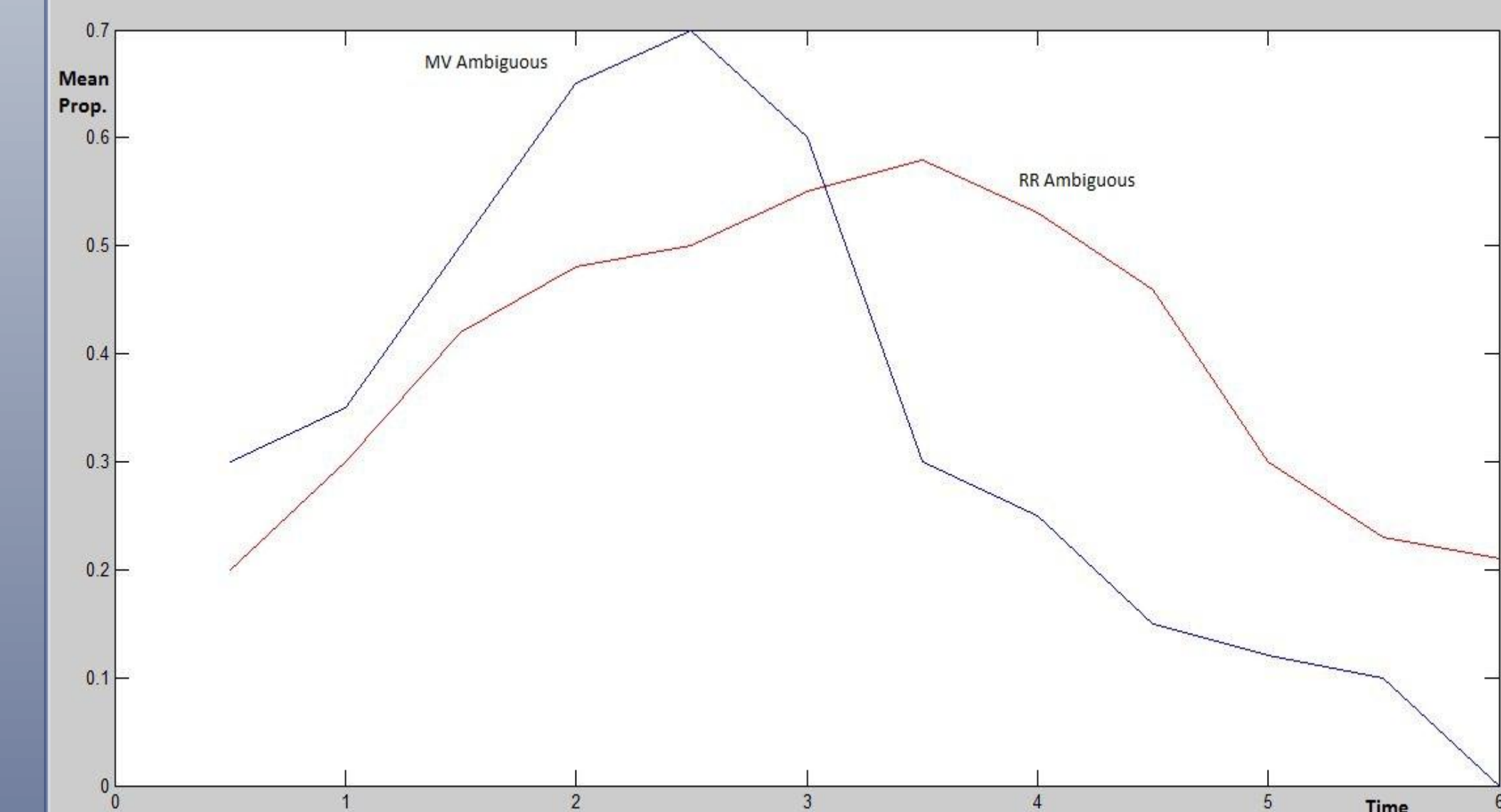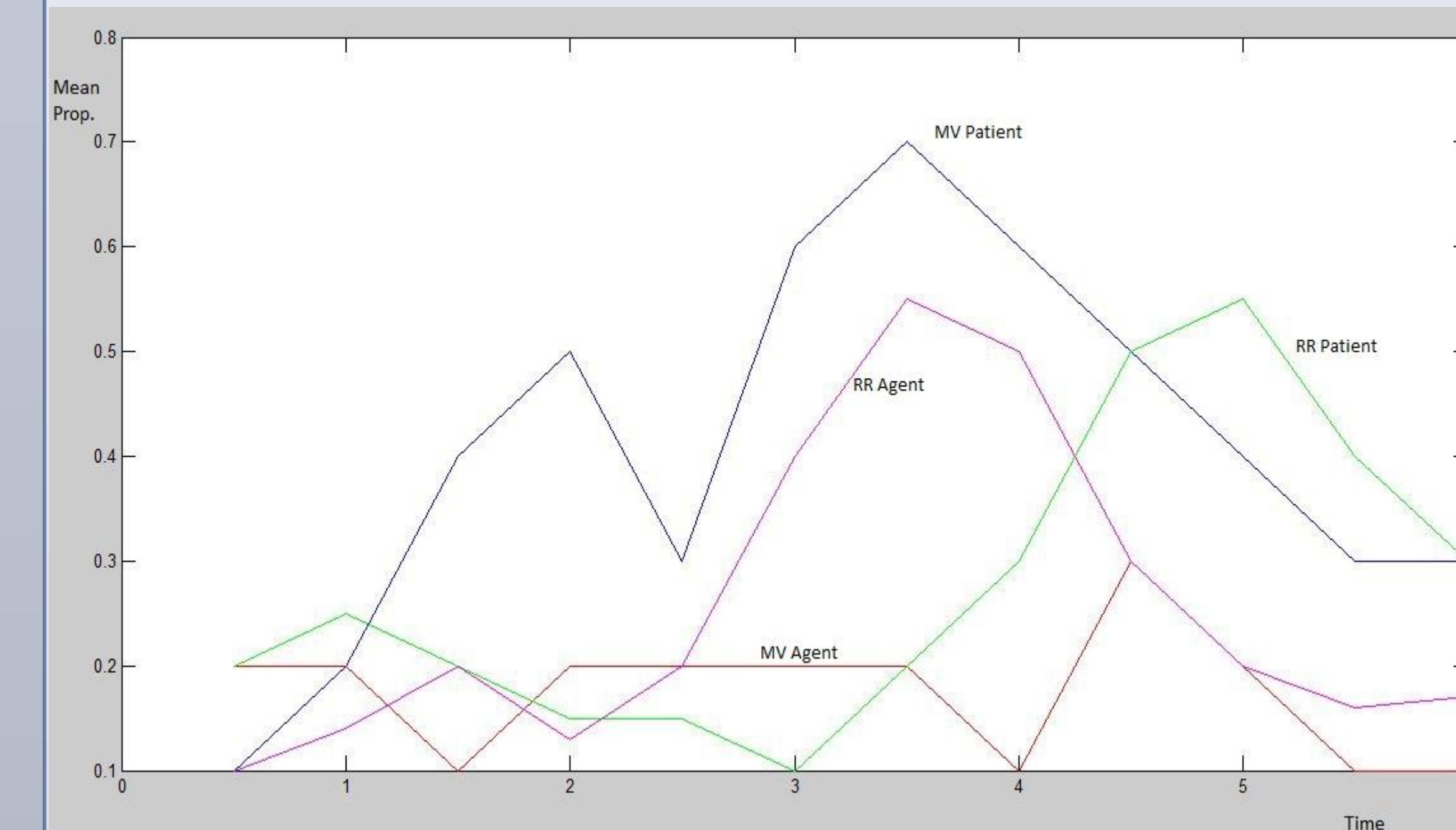
Conclusion

The gaze proportion graphs suggest disambiguation and comprehension of thematic roles of the characters after the verb has been uttered since the gaze proportion is more on the patient in first sentence and on the agent in the second sentence. The final plots also show that the expectation of the patient just after the verb has been uttered.

References

References:

Pia Knoeferle, Matthew W. Crocker: The Coordinated Interplay of Scene, Utterance, and World Knowledge: Evidence From Eye Tracking

Paola Merlo, Suzanne Stevenson: Language acquisition and Ambiguity Resolution: The role of frequency distributions

Acknowledgement