CHAPTER 2

SERIES OF EXPERIMENTS
Chapter 2

Experiment 1

Speech-mediated eye gaze in Urdu: Time course of phonological and morphological activations

Introduction

The complex linguistic structure and opaque orthography of a language is greatly dependent with regard to the dynamics of reading and comprehension. Research in speech-mediated eye movements and ERP suggests linguistic predictions can be based on morphological (Altmann & Kamide, 1999), syntactic (Kamide, Scheepers, & Altmann, 2003) and phonological (DeLong, Urbach, & Kutas, 2005) information.

Also, reading processes are understood to be influenced by linguistic and visuo-perceptual factors. Research in behavioral studies suggest that visual characteristics of words, like directionality (Eviater, 1995; Vaid, 1998), word length (Aghababian & Nazir, 2000), orthographic and morphological structure (Deutsch & Rayner, 1999; Farid & Grainger, 1996), orthographic depth (Katz & Frost, 1992) and visual complexity (Rao, Vaid, Srinivasan, & Chen, 2011) affect word recognition.

Furthermore, studies using the printed version of visual world paradigm reported graded sensitivity to phonetic detail (Huettig & McQueen, 2007;
McMurray, Aslin, Tanenhaus, Spivey, & Subik, 2008; McMurray, Tanenhaus, & Aslin, 2002), lexical stress on initial syllable (Reinisch, Jesse, & McQueen, 2010) and functionality of orthography (Frost & Ziegler, 2007; Salverda & Tanenhaus, 2010) were time-locked and automatic to the speech being unfolded and that there is virtually no delay in processing phonological and orthographic information during speech perception.

This paper attempts to understand processes underlying word recognition in Urdu, an Indo-European language. The grammar, phonology and morphology of Urdu mime Hindi on one end and mime Arabic with regard to its orthography and lexicon (Mirza, 2014).

The Urdu lexicon is considered to be an amalgamation of native Urdu, Persian and Arabic borrowings resulting in a complex morphology. Word formation in Urdu includes analytic, synthetic and agglutinative elements (Rao, 2010). The Urdu lexicon requires agreement with morphological markers across grammatical categories to achieve morphological distinctions (Rao, 2010). The ‘tri-consonantal root-word pattern’ of Arabic morphology is unknown to Urdu (Islam, 2011). Urdu borrows the tri-consonantal root in its lexicon. However, loan words may be considered as whole words, as in the source language or nativized for
gender, number or case marking with addition of suffixes or deletion of aspirations (Islam, 2011).

For example: 1. the root $zlm$ ظ ل م forms the word $zulm$ ظ (tyranny) used as it is in Arabic and is also nativized with a suffix ‘i’ $zulmi$ ظ (tyrant).

2. A Persian stem $bəʃa(h)$ ‘child’ ʃا is nativized as $bəʃa$ ʃ in Urdu with the deletion of aspiration ‘h’.

The derivations are restricted to some patterns and each loan pattern contains only a few derived words is used in the same way as in the original form and show changes by some affixation, modification of base and phonology (Islam, 2011). Thus, Arabic loan-words are well accommodated in Urdu.

**Orthographic complexity in Urdu**

In Urdu, like Arabic and unlike Hebrew, dots comprise an integral part of the alphabet and the number of dots assigned to the letter gives it phonetic value. There are many homographs in Urdu and the number of dots under or above the homograph differentiates the alphabet with its
phonetic value ex. \( be \), \( pe \), \( se \) and \( te \). Letters are represented in different shapes owing to the position of occurrence (initial, medial or final) and differentiated as connectors (most of the alphabets) and non-connectors (six). The non-connecters connect only to the right that causes space within words and ambiguous word boundaries (Mirza, 2014). Though Arabic loanwords in Urdu are represented with the same letter as in Arabic it carries a native Urdu pronunciation resulting in many homophone graphemes. Ex. The alphabets \( sin \), \( se \) and \( suad \) have an altered single phoneme ‘s’.

The Persio-Arabic script of Urdu is written without vowel markers in the right-to-left direction, similar to Arabic, Persian and Hebrew orthographies. The unvowelized nature, loanword morphology, complex phonology, and visually complex deep orthography tend to make the task of reading a complex phenomenon.

The authors believe, till date, that studies regarding the role of morphology and effect of homophony in word recognition in Urdu have never been attempted, especially in eye movement research. Hence, we
designed an experiment to investigate the time course of phonological and morphological interference during Urdu word recognition.

Considering the visually complex orthography, ambiguous phonology and rich morphology of Urdu, we hypothesize interference of homophone graphemes and morphological cues during word recognition. We expect to see significant differences in relative proportion of fixation durations between target word, distractors and competitors. We also hypothesize that there would be differences in proportion of fixation duration among children and adults with regard to the point of resolution.

Here, we discuss a ‘look and listen’ study in Urdu wherein we use phonological and morphological competitor trials to compare the morphological and phonological interferences with processing of target words in a printed version of the ‘visual word paradigm’.

Paradigm

We adopted the printed version of ‘Visual world paradigm’ for this experiment, wherein participants heard utterances while looking at a visual display of target word, competitors and distracters. The display occurred along with the spoken utterance and eye movement measures were recorded online.
Participants

Twenty-five high school students, in the age group of 14 -16years, and 25 Undergraduate students in the age group of 20 - 25 years participated in the study. All participants were studying with Urdu as their medium of instruction in their elementary school and Urdu as their first language of study at undergraduate level. Their mother tongue was Urdu. Informed consent was taken before the experiment commenced. They were paid for their participation. All participants had normal vision and hearing.

Stimuli Material

The words for the experiment were chosen from high school text books and newspapers. These words were rated for frequency on a 7 point scale with 1 as ‘highest in frequency’ and 0 as ‘never heard’. Length of each word was 3 to 6 letters. A total of 500 words were listed and were marked by 35 professionals. They did not participate in the experiment and were oblivious of the purpose of marking. They were instructed to mark the words according to the frequency of occurrence of the word in print. 40 high frequency words were selected for the experiment after evaluating the results.

Method

The experiment had the following three conditions: (i) Target word with three unrelated distractors (ii) Target word, a phonological competitor
(orthographic manipulation), and two unrelated distractors. The homophone letter was replaced in the initial position of the target word and could be pronounced in the same way as the target word, ex. Target word ‘aashq’ (a fan/ lover) عاشق would be written as عاشق where ain ع was replaced with َ alif madd its phonological competitor and two unrelated distractors (iii) Target word, a morphological competitor and two unrelated distractors ex. Target word aashiq عاشق and a morphological competitor aashoora عاشورا and two unrelated distractors

Each set had four words in the visual display. 40 visual displays were constructed for each condition with a total of 120 experimental trials. In addition, 80 filler trials were constructed.

Each experimental and filler stimuli was framed into a sentence in such a way that the target word always appeared in the third position of the sentence thereby giving no clue of the context till the acoustic offset of the target word. Sentences were recorded in a sound-proof room by a proficient male native speaker. The mean duration of the target word was 437ms. For precision, there was a break after half experimental trials and the experiment continued after recalibration and validation.
Design

The visual display had the four words equally spaced at the right and left corners of the screen with a distance around 6cms horizontally and 9.5cms vertically from the centre of the word (Figure1). The position of target word and competitor were randomized to avoid the possibility of any guess-work by the participants. All the trials were randomized. Each visual display lasted for 5000ms. Acoustic onset of the target word from the visual display was at about 1088ms, duration of the target word lasted for about 437ms and the spoken sentence ended at about 3.47ms. An SMI eye tracker of 1250Hz resolution was used to collect data.

![Figure1: Visual display of stimuli](image)

Procedure

After successful calibration the experimental trial began with a fixation cross at the centre of the screen for 700ms followed by presentation of four words being displayed as the stimulus. A spoken sentence with the target word was presented through headphones. In a ‘look and listen’ task, the participants were instructed to carefully hear the sentence and look at the screen. They were told not to take their eyes off the screen.
Eye movement measures were recorded online. Each trial lasted for 700ms + 5 seconds. Each experimental session lasted for about 30 minutes. 10 experimental trials were selected for practice and appeared at the beginning of the experiment in order to help participants familiarize themselves with the experimental task and procedure.

![Fig. 2 Procedure showing display of stimuli in a visual world paradigm](image)

Trial changes when the acoustic signal ends.

Acoustic signal starts with display

**Data Coding**

Fixation duration to target word, competitor, and distractor being directed towards a given word if it fell within the predefined AOI of 4x4.5cms from the centre of the word were considered for analysis. Fixation durations outside this area of interest were not considered for analysis. The mean of fixation duration was converted into proportions and then arcsine transformed following the procedure adapted by (A.P Salverda et al., 2007) to improve normality and homoscedasticity of the data before statistical analysis.
Results

One trial was excluded from analysis because of experimental error. The proportion of fixation duration to target word, distractor, and competitors were statistically analysed to infer the relative interference of phonology and morphology in processing Urdu words.

We examined the results in two different ways to understand the time-course of fixation duration.

1. At first, we examined relative proportion of fixation duration in three timelines – 1. From onset of visual display to acoustic onset of target word (average mean duration 1088ms), henceforth called Time 1 (T1) 2. During acoustic presentation of target word (onset-offset) (average mean duration 437ms), Time 2 (T2). 3. After 200ms acoustic offset of target word (mean duration 200ms) Time 3 (T3).

2. For a fine grained analysis, we examined the relative proportion of fixation duration for every 100ms time bin from the beginning of the visual display till its end.

The arcsine transformed proportion of fixation duration in the three timelines (T1, T2, T3) for three conditions were statistically analysed. The
average mean of fixation duration for children and adults for three timelines are given in table 1.

Table 1: Avg. Mean of fixation duration to target word, distractors, and competitors of three conditions in three timelines for children and adults.

<table>
<thead>
<tr>
<th>Condition Object</th>
<th>Fixation Proportions from onset of visual display to acoustic onset of Target word</th>
<th>Fixation Proportions from acoustic onset to acoustic offset of Target word</th>
<th>Fixation Proportions from acoustic offset of Target word to +200ms after acoustic offset of Target word</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Children</td>
<td>Adults</td>
<td>Children</td>
</tr>
<tr>
<td><strong>C1</strong></td>
<td>Target</td>
<td>261.9</td>
<td>234.52</td>
</tr>
<tr>
<td></td>
<td>Distractor</td>
<td>262.43</td>
<td>208.07</td>
</tr>
<tr>
<td><strong>C2</strong></td>
<td>Target</td>
<td>233.54</td>
<td>240.41</td>
</tr>
<tr>
<td></td>
<td>Distractor</td>
<td>225.81</td>
<td>149.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td>262.01</td>
<td>204.03</td>
</tr>
<tr>
<td><strong>C3</strong></td>
<td>Target</td>
<td>223.19</td>
<td>214.97</td>
</tr>
<tr>
<td></td>
<td>Distractor</td>
<td>233.59</td>
<td>147.35</td>
</tr>
<tr>
<td></td>
<td>Morphological competitor</td>
<td>240.06</td>
<td>239.38</td>
</tr>
</tbody>
</table>
A 2x3x3 factorial analysis i.e. two groups (children and adults) x three time lines x three conditions) with the last two factors repeated was done. The analysis revealed relative proportion of fixation duration to Target word between groups was highly significant (F = 33.562, df -1, p=0.001). This indicates that reading skills were different for children and adults. The interaction effect was significant across conditions, time and groups hence the main effects on conditions and time may have been affected by the differences in group (see table2) and fig3-7.

Table.2 Repeated measures ANOVA for main and interaction effect.

<table>
<thead>
<tr>
<th>Repeated measures ANOVA</th>
<th>Test within subject effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>df</td>
</tr>
<tr>
<td>Conditions</td>
<td>2</td>
</tr>
<tr>
<td>Time</td>
<td>2</td>
</tr>
<tr>
<td>Cond x group</td>
<td>2</td>
</tr>
<tr>
<td>time x group</td>
<td>2</td>
</tr>
<tr>
<td>cond x time</td>
<td>4</td>
</tr>
<tr>
<td>cond x time x group</td>
<td>4</td>
</tr>
</tbody>
</table>

Paired t test for children and adults between target word and phonological competitor and target word and morphological competitor across the three time lines revealed no significant differences in case of children
across the three timelines while mixed results were obtained for adults.

We did not obtain significant differences for both target word and
competitors in T1, significant differences were seen for target word and
phonological competitor in T2 but no significant differences between
target word and morphological competitor was observed and significant
differences for both target words and competitors was obtained in the
third timeline T3 (see table 3)

Table3. Paired $t$ test for children and adults between target words and
competitors across three timelines

<table>
<thead>
<tr>
<th></th>
<th>Children</th>
<th></th>
<th>Adults</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$T$</td>
<td>df</td>
<td>$P$</td>
<td>$t$</td>
<td>df</td>
</tr>
<tr>
<td>T1(0-0nset)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TW-PC</td>
<td>0.32</td>
<td>40</td>
<td>0.74</td>
<td>0.71</td>
<td>38</td>
</tr>
<tr>
<td>TW-MC</td>
<td>0.3</td>
<td>40</td>
<td>0.76</td>
<td>0.77</td>
<td>38</td>
</tr>
<tr>
<td>T2 (Onset-offset)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TW-PC</td>
<td>1.34</td>
<td>40</td>
<td>0.18</td>
<td>2.25</td>
<td>38</td>
</tr>
<tr>
<td>TW-MC</td>
<td>0.08</td>
<td>40</td>
<td>0.93</td>
<td>1.31</td>
<td>38</td>
</tr>
<tr>
<td>T3 (Offset- +200ms)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TW-PC</td>
<td>0.24</td>
<td>40</td>
<td>0.81</td>
<td>2.84</td>
<td>38</td>
</tr>
<tr>
<td>TW-MC</td>
<td>1.8</td>
<td>40</td>
<td>0.07</td>
<td>4.03</td>
<td>38</td>
</tr>
</tbody>
</table>
Fig3. Graph showing interaction effect for group x conditions

Fig4. Graph showing interaction effect between group and time.
Fig 5. Graph showing interaction effect between group x conditions at time 1 (T1).

Fig 6. Graph showing interaction effect between group and conditions at time 2 (T2).
Fig 7- Graph showing interaction effect between group and conditions at time 3 (T3).

**Discussion**

Previous research on phonological competition suggests a strong competition effect between target word and its phonological competitor at word onset rather than at word offset (Allopenna, Magnuson, & Tanenhaus, 1998; Magnuson, Tanenhaus, Aslin, & Dahan, 2003). Additionally, researchers attributed the divergent patterns in morphological processing in European and Semitic languages to the differences in morphological structure of the respective languages (Plaut & Gonnerman, 2000). Urdu seems to be sandwiched between these two
language systems with its linguistic roots in Hindi and orthography in modified Arabic resulting in a complex morphological structure, changed phonology and an opaque visually complex orthography (Rao, Vaid, Srinivasan, & Chen, 2011). Furthermore, the authors’ report that readers in Urdu may rely on the direct route to lexical access and have a morphological advantage in comparison to Hindi readers.

In a printed version of the visual world paradigm (Huettig & McQueen, 2007), we tracked the time course for relative proportion of fixation duration and observed activation of target word, distractors, and competitor for every 100ms time-bin and in three timelines. Our observations were based on the conclusions by Huettig and McQueen’s (2007) critical review that orthographic information was parallelly activated and mapped automatically in a time-locked manner as a consequence of hearing spoken word (Huettig & McQueen, 2007).

The paired t test revealed skill in reading as an important factor and that linguistic feature of a language play a more dominant role. While skilled readers resolved homophony during acoustic presentation of target word, both children and adults took more time to resolve morphological competitor.
Fig 8: Point of resolution of relative proportion of fixation duration to target word and unrelated distractors in condition 1 over a time-course of visual display (children)

Fig 9: Point of resolution of relative proportion of fixation duration to target word, homophone competitor and unrelated distractors in condition 2 over a time-course of visual display (children)
Fig 10: Point of resolution of relative proportion of fixation duration to target word, morphological competitor and unrelated distractors over a time-course of visual display (children).

Fig 11: Point of resolution of relative proportion of Fixation duration to target word and unrelated distractors in condition 1 over a time-course of visual display (adults).
Fig 12: Point of resolution of relative proportion of fixation duration to target word, phonological competitor and unrelated distractors in condition 2 over a time-course of visual display (adults).

Fig 13: Point of resolution of relative proportion of fixation duration to target word, morphological competitor and unrelated distractors in condition 2 over a time-course of visual display (adults).
Additionally, we studied the relative proportion of fixation duration to target word, competitors and distractors to see at what point in time competition got resolved for children and adult during word recognition.

We observed that the distractors were rejected in all the three conditions at almost the same time for both children and adults. This indicates that distractors did not compete during lexical access because they were not phonologically, orthographically or morphologically related to the target word.

Our observation of delay in resolution time in children as compared to adults where there was no competition points out that the differences in developing and skilled reading during target words when there was no competition.

Furthermore, though readers in Urdu are tuned to use specific letters for Arabic loanwords and words of Indic origin, readers seem to have not mastered the concept of homophone graphemes. Ex the letters $\text{ـس}$, $\text{ـث}$ and $\text{ـص}$ represent the same phoneme ‘$s$’, the Arabic loanwords use $\text{ـص}$ and $\text{ـث}$ while only the letter $\text{ـس}$ is used in words of Indic
origin. Where children took more time to resolve phonological competition, we observed phonological competitor closely competed with the target word in case of adults. It seems to be evident that readers in general take more time to disambiguate the correct letter as against its homophone equivalent. Nevertheless, the immediate rejection of phonological competitor in case of adults does signal skilled reading.

Surprisingly, both children and adults took almost equal time to resolve morphological competition hinting morphology to play a more dominant role in lexical access and seem to be more inhibiting than facilitating during word recognition even in skilled readers.

More intriguing is that target word recognition in Urdu takes more time as compared to English studies. While it takes +200ms after acoustic offset of target word in English when there is no competition, we observed that children took almost 500ms and adults took around 400ms to recognize the correct target word even when there was no competition. This is considered to be a new finding in processing time during word recognition especially in Urdu. We assume that the differences in processing time may be due to the amalgamated morphology, homophony and visually deep complex orthography.

However, the results are in line with previous research that phonological and orthographic information are parallelly activated and are time-locked
(Huettig & McQueen, 2007; Salverda & Tanenhaus, 2010) as a consequence of hearing a spoken word. Nevertheless, homophony still plays a significant role and morphology seems to act as a detrimental factor in word recognition in case of Urdu.

Therefore, we conclude that word recognition is automatic, spontaneous and unconscious in skilled reading. A comparative study between children and adults concludes that while orthographic and morphological factors levy a processing cost in children, morphological factors are more pronounced during word recognition in skilled readers.

The experiment on effect of phonological and morphological competitor revealed morphology to play a more dominant role. Participants in the experiment took more time to resolve morphological competition than phonological competition. This gave us a new objective as to why morphology played a dominant and detrimental role in case of Urdu. We designed a simple word recognition experiment to see the difference in response time for morphologically related stimuli during lexical access.
Experiment 2

Word Recognition in Urdu

Introduction

Urdu is an Indo-Aryan language with a Persio-Arabic script. Its linguistic roots, grammar and lexicon are based on Sanskrit. It also borrows lexicon, non-concatenative feature, tri-consonantal root, orthography and the like from Arabic, a Semitic language. Although the salient feature of tri-consonantal root and word pattern seen in Arabic is unknown to Urdu, the basic rule of word formation is similar in Urdu. In other words, words in Urdu are formed from the tri-consonantal root combining with vowels or consonants to form words. The root is the basis of a words’ structure and the affixation of vowels and consonants give grammatical category. The root and the affixation are an integral part of word formation in Urdu. The loanwords undergo nativization processes with Arabic, Persian or Indic affixation and hence bring about changes in phonology and modification of base (Islam, 2011).

Like Hebrew/Arabic and unlike English, word recognition in Urdu is of special interest because words are context specific and get their phonology accordingly, e.g. کیا can be read as kya or kiya. Letters have different size and shapes according to the position they occur in the word. Words are phonologically opaque as letters mostly carry consonantal
information and diacritical markers are omitted rendering Urdu with a phonologically opaque, visually complex orthography and a complex morphology (Khan, 2014).

Studies in processing inflected and derived forms have shown mixed results. While some studies produced similar effects, others reported larger effects for inflections than derivations (Feldman, 1994; Raveh & Rueckl, 2000; Sanchez-Casas, Igoa, & Garcia-Albea, 2003). Evidence from masked priming studies suggests automatic morphological decomposition (Rastle, Davis, Marslen_Wilson, & Tyler, 2000) and that any word is first decomposed into its respective stem and affix for derived and inflected word forms (Meunier & Marslen_Wilson, 2004). These studies and a few others converge with evidence for automatic morphological segmentation independent of word meaning (Morris, Grainger, & Holcomb, 2008).

The present study is interesting in the sense that both inflectional and derivational word forms share same letters (orthographic overlap) but are different functionally. The inflectional forms carry the grammatical category and syntactic function without changing the basic meaning of the base while the derivational word forms contribute to the thematic role, have no syntactic function, indicate grammatical category and are specially implicated in the semantic variation of words. This is very
similar to Hebrew (Alvarez, Urrutia, Dominguez, & Sanchez-Casas, 2011).

We hypothesized that response time for base word and derivatives would be faster than inflectional word forms. We expected this because base words and derivatives are whole word forms while the extensions (inflections) have affixations. We expect whole word processing in the former and Taft and Forster’s model of prefix stripping (Taft & Forster, 1975) in the latter. We also expected to see if word length was a confounding factor during word recognition. Additionally, we hypothesized differential processing strategies between extensions (inflection) and derivative word forms.

**Participants**

Thirty undergraduate students between the age groups of 20-25 years (Mean age 21.67, SD 2.41) participated in the study. All participants had studied with Urdu as the medium of instruction in elementary school and as the first language of study at undergraduate level with Urdu as their mother tongue. They were paid for their participation. All participants had normal/corrected vision and normal hearing.

**Stimulus Material**

500 words were selected from school text books and newspapers and were tested for frequency on a 7 point scale. 120 words that were marked
as high frequency words out of the 500 listed words were chosen for the experiment. Target words in each condition had 40 Arabic loan words in Urdu. Condition 1 was the base-word formed from the tri-consonant root, condition 2 stimuli words were the extensions (inflectional forms) of the base-word, and in condition 3 target words were derivatives and morphologically related to the base-word. Frequency for all the stimuli across conditions was controlled (see Table 1). The target words in condition 1 had 26 nouns and 14 adjectives, condition 2 had 28 nouns and 12 adjectives and condition 3 had 30 nouns and 10 adjectives. The word type could not be controlled because when the base word undergoes nativization with affixation the resultant word is either a noun or an adjective. A total of 120 words were chosen for three conditions. Word length was between 3 to 6 letters in length. Word length of target words in condition 1 was 3-4 letters and condition 2 and 3 was 4-6 letters (see Table 1). Fig 1 is an example of stimuli type used across three conditions in the experiment.

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>عاضر</td>
<td>haa'zr</td>
<td>attend</td>
</tr>
<tr>
<td>C2</td>
<td>ناشري</td>
<td>Haa'zri</td>
<td>attendance</td>
</tr>
<tr>
<td>C3</td>
<td>ضيفرت</td>
<td>Haz'rat</td>
<td>honorific term for Mr.</td>
</tr>
</tbody>
</table>

Fig 1-Stimuli type for three conditions used in the experiment.
Procedure

Stimuli were presented using E-Prime experimental software in a simple word recognition task. Each trial started with a “+” sign at the centre of the screen on which the subjects were asked to fixate. This display lasted for 500ms and was followed by a ‘target screen’ with the target word appearing at the centre and remained on the screen until the participants responded. The ‘ready screen’ would allow the participants to go to the next trial.

Participants were instructed to look at the “+” sign and recognize the word in the display as fast as they could and press space bar. When the ‘ready screen’ appeared they were asked to write the word they just saw. This was done to ensure accuracy during the experimental trial. Response times from the onset of the target word until the participant responded were considered as dependent variable.

Fig2- Presentation of stimuli
Participants were presented with 10 practice trials before the experimental trials started. Each participant was presented with 120 trials. All trials were randomized ensuring no trial repeated.

**Results**

RTs were averaged across subjects and across items. The effect of outliers was minimized by establishing cut-offs 3 standard deviation units above and below the mean for each participant and item.

The mean and standard deviations for response time (RT), word length (WL) and word frequency are provided in Table 1. We performed the data analysis with a repeated measure analysis of variance (ANOVA). The obtained F ratio was significant (F (2, 58) = 9.92; \( p = 0.000 \)). The post hoc (Bonferroni) analysis revealed significant difference between conditions C1-C2 and C1-C3 and no significant differences were observed between conditions and C2-C3 (C1-C2- \( p = 0.05 \); C1-C3- \( p = 0.00 \) and C2-C3- \( p = 0.13 \)).
Table 1 - Average mean and SD for Response time, word length and frequency of stimuli for three conditions.

<table>
<thead>
<tr>
<th></th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>RT</td>
<td>874.89</td>
<td>587.17</td>
<td>982.58</td>
</tr>
<tr>
<td>WL</td>
<td>3.65</td>
<td>0.66</td>
<td>4.78</td>
</tr>
<tr>
<td>Freq</td>
<td>2.89</td>
<td>0.82</td>
<td>2.63</td>
</tr>
</tbody>
</table>

**Discussion**

Research in different languages suggests that recognition of printed words depends on the match between a printed letter string and a lexical representation (Frost, Katz, & Bentin, 1987). This can be mediated either based on some abstract representation of orthography or that which refers to phonemic information represented by the graphemic structure (Frost et al., 1987). Nevertheless, both the orthographic and phonemic codes are activated automatically during the process of word recognition (Humphreys & Evett, 1985). Another possibility added to the above two aspects is the role played by the orthography depth of the language (Lukatela, Popadic, Ognjenovic, & Turvey, 1980).

The experiment on word recognition with different word-class (base, extension (inflection) and derivative forms) revealed mixed results. We observed significant differences in processing between condition 1 and 2
and condition 1 and 3 but no significant differences between condition 2 and 3. This suggests differential processing strategies for each condition. Though word length was significant, its effect does not seem to be a confounding factor. This may be because words in Urdu are visually complex, phonologically opaque and orthographically compact. Additionally, a comparative study of Hindi and Urdu showed word length influenced only on low frequency words (Vaid, Rao, Chen, Kar, & Sharma, 2008). The response time for the base words was fastest and derivational form was slowest. This clearly states that it takes more time to decipher derived word forms. We assume that participants took more time to recognize extension (inflectional) and derivational word forms because these words are formed by affixations. We observed no significant differences in processing between conditions 2-3 clearly suggesting target-words had to be first stripped off into their respective stems and affixes or morphologically segmented before they were recognized. The results seem to be in line with Taft and Forster’s model of prefix stripping.

This experiment reports differential processing of base words, its extension and derivations. We also observed that word length did not affect lexical access. The experiment acted as a forerunner to see if presentation of the root letters in the parafovea had any effect on lexical
processing in the fovea. Therefore, the next experiment added the tri-consonantal root in the parafovea to see changes in lexical processing in the fovea. We wanted to see if the facilitatory role of tri-consonantal role observed in Hebrew would be similar in Urdu. We hypothesized so as word formations in Urdu are similar to word formations in Arabic and Hebrew.
Experiment 3

Parafoveal Preview Benefit in Urdu

Introduction

Word identification often starts before the eyes fixate on a target word as readers get information from the parafovea (Rayner, Pollatsek, & Binder, 1998). When the information is extracted from the parafovea there is partial activation of lexicon and this activation is integrated with subsequent activation from the foveal word (Rayner, McConkie, & Zola, 1980). Parafoveal preview benefit is derived from abstract letter codes (McConkie, 1979; Rayner et al., 1980), orthographic codes from the beginning letters of a word (Inhoff, 1989; Rayner, Well, Pollatsek, & Bertera, 1982) and phonological codes (Handerson, Dixon, Patterson, Twilley, & Ferreira, 1995; Pollatsek, Lesch, Morris, & Rayner, 1992). However, while studies in English showed no morphological preview benefit (Inhoff, 1989; Kambe, 2004; Lima, 1987) robust preview benefit was observed in Hebrew (Deutsch, Frost, Pelleg, & Rayner, 2002; Deutsch, Frost, Pollatsek, & Rayner, 2000).

Parafoveal preview benefit is either assessed in the context of a sentence or in single word identification. When assessing for parafoveal preview benefit during sentence reading, duration of fixation on the target word is measured for single word naming.
Studies in Hebrew and other languages suggest that preview of morphologically related words induce a priming effect on target words (Bentin & Feldman, 1990; Deutsch et al., 2000) since morphological units may help in organizing mental lexicon and may mediate lexical access. The morphological analysis of an upcoming word during reading may be influenced by an on-going processing of the sentence context (Deutsch et al., 2002). The process of lexical access may consist of both lexical retrieval of whole words and a mandatory parallel processing of morphological decomposition.

Urdu, like Hebrew, has a non-concatenated derivational morphology. All verbs and a majority of nouns and adjectives are comprised of two basic derivational morphemes: root and word pattern as seen in Semitic language. The root consists of three consonants and word pattern consists of vowels or consonants and vowels. Root usually carries the core meaning of the word and word pattern determines its word class and other grammatical characteristics.

Hebrew has great internal variability in the distributional properties of the morphemes and semantic transparency. But the morphemes in Urdu are not necessarily contiguous units within a given word. They often obscure the phonological and orthographic transparency of constituent morphemes.
Findings in Hebrew (Deutsch et al., 2000) suggest that: a) Naming is fastest for the identical words (same preview and target word); b) a significant preview benefit effect of 12ms is observed when preview consists of the root; c) morphological units mediate word identification in Hebrew; d) a parafoveal presentation of letters with root morphemes facilitates identification of target word, since root words can be dispersed within a word; e) Hebrew presents a unique case where a sub-lexical unit that mediates lexical access does not have linear characteristics. Thus in languages like French and English, readers may attend to first letters of a word to initiate lexical processing but in Hebrew readers may be tuned to attend morphological units in word identification. Given the reported similarities between Hebrew and Urdu, these findings serve a sure forerunner for making a hypothesis for the present study. We hypothesized that the presentation of root letters in the preview should differentially influence response time for recognition of stem/base word, extension (inflectional) word, and derivative forms.

**Participants**

Thirty Undergraduate students between the age group of 20- 25 years (Mean age= 21.67; SD=2.41), who studied Urdu as their first language throughout their education and whose mother tongue was Urdu participated in the study. They were paid INR 50.00 for their
participation. Every participant had normal/corrected vision and normal hearing. Informed consent was obtained by all the participants. The study was approved by the Research Committee constituted by the University for the candidate.

**Stimulus Material**

The stimulus words were Arabic loanwords in Urdu with tri-consonantal root as in Arabic. The experimental set had presentation of stimuli with a preview of Arabic tri-consonantal root in the parafovea and a target in the foveal region. The target words were formed from root letters across three conditions. Each condition had 40 Arabic loan words. Condition 1 (C1) had the base word, condition 2 (C2) had extensions of the base-word (inflections) and condition 3 (C3) had derivative of the base-word or the root letters. The preview was tri-consonants root for all the conditions. A total of 120 words were chosen for three conditions. Word length of target words in condition1 was 3-4 letters (Mean length=3.65; SD = 0.66) and in conditions 2 and 3 was 4-6 letters (C2: Mean= 4.78, SD=0.65; C3: Mean=4.8, SD=0.75). The root letters that form all the target words across conditions were of 3 letters each, meaningless and not pronounceable. The letter sequence of the target word in the base-word and extension condition was similar to the arrangement of roots in the
preview and was not the same in the derivative condition most of the time (see Fig1).

<table>
<thead>
<tr>
<th></th>
<th>Preview</th>
<th>Target</th>
<th>Transliteration</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1- stimuli with identical words as the roots</td>
<td>اَحْرَر</td>
<td>اَكْحَر</td>
<td>Aakhir</td>
<td>unchangeable, imperishable</td>
</tr>
<tr>
<td>C2- Stimuli with an extension of the words in C1</td>
<td>اَحْرَر</td>
<td>اَكْحَرِي</td>
<td>Aakhari</td>
<td>last, final</td>
</tr>
<tr>
<td>C3- Stimuli with Derivatives of the root word used in C1</td>
<td>اَحْرَت</td>
<td>اَكْحِرَت</td>
<td>Aakherat</td>
<td>afterlife, the ultimate, the ending</td>
</tr>
</tbody>
</table>

Fig1. Stimuli type for three conditions used in the experiment.

**Procedure**

Stimuli were presented using E-Prime experimental software in a simple priming parafoveal preview benefit task. Each trial started with a “+” sign at the centre of the screen on which the subjects were asked to fixate. This display lasted for 500ms and was followed by a ‘preview screen’ which consisted of a “+” sign in the centre and a preview stimulus located to the left of the plus sign. The distance between the “+” sign and the first character of the preview stimulus was about 3° visual angle. The preview stimulus was timed at 50ms. The ‘preview screen’ was replaced by a ‘target screen’ with the target appearing at the centre and remained on the screen until the participant responded. The ‘ready screen’ would allow
the participant to go to the next trial. Participants were instructed to look at the “+” sign and recognize the word in the display as fast as they could. When the ‘ready screen’ appeared they were asked to write the word they just saw. This was done to ensure reading accuracy. Response time from the onset of the target until the participants responded was considered as dependent variable (see Figure 1).

![Figure 2. Presentation of stimuli](image)

Participants were presented with 10 practice trials before the experimental trials started. Each participant was presented with 120 trials for each experiment. All trials were randomized ensuring no trial repeated.

**Results**

RTs were averaged across subjects and across items. The effect of outliers was minimized by establishing cut-offs 3 standard deviation units above and below the mean for each participant and item.
The mean and standard deviations for response time (RT) and word length (WL) are provided in Table 2. We performed the data analysis with a repeated measure analysis of variance (ANOVA). The obtained F ratio was significant \( (F(2, 58) = 7.902; p = 0.001) \). The post hoc analysis (Bonferroni) revealed significant difference between conditions C1 and C3 \( (p = 0.007) \) and conditions C2 and C3 \( (p = 0.031) \). No significant difference was observed between conditions C1 and C2 \( (p = 0.632) \).

A one-way ANOVA for word length for target word across conditions revealed significant differences \( (F = 16.3, \text{df}= 2, p = 0.00) \) and post hoc analysis (Bonferroni) revealed significant differences in word length between condition 1 and condition 2 \( (p = 0.01) \) as well as condition 1 and condition 3 \( (p = 0.01) \) but no significant difference was observed between condition 2 and condition 3 \( (p = 0.66) \).

Table 1. Mean and SD for response time and word length for three conditions (C1, C2, C3)

<table>
<thead>
<tr>
<th></th>
<th>C1</th>
<th></th>
<th>C2</th>
<th></th>
<th>C3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td><strong>RT</strong></td>
<td>581.4</td>
<td>143.45</td>
<td>624.39</td>
<td>123.9</td>
<td>678.21</td>
<td>156.83</td>
</tr>
<tr>
<td><strong>WL</strong></td>
<td>3.65</td>
<td>0.66</td>
<td>4.78</td>
<td>0.65</td>
<td>4.8</td>
<td>0.75</td>
</tr>
</tbody>
</table>
Discussion

The focused attention model of parafoveal processing (McConkie, 1979; McConkie, Zola, Blanchard, & Wolverton, 1982; Morrison, 1984) suggests that reading proceeds through a sequential identification of words in the foveal vision and partial information about the word is obtained parafoveally. Preview benefit is recorded in many languages. The benefit is a function of the visual and phonological similarities between preview word and target word (Pollatsek et al., 1992). Studies in Chinese (Lee, 2000; Tsai, Tzeng, Hung, & Yen, 2004) observed that phonetic radicals have a privileged role in early stage of character identification and that phonological codes might be slower or less important than orthographic coding. However, studies that employed naming task (Cheng & Shib, 1988) and semantic judgement task (Perfetti & Zhang, 1995) suggested that phonological and/or orthographic preview benefit could be additive. These findings have been explained by the current reading models like the interactive-activation models (Plaut, McClelland, Seidenberg, & Patterson, 1996; Seidenberg & McClelland, 1989).

Presentation of root letters in the preview, in the present study, resulted in shorter response time for base words as compared to derivative words. The difference between mean RTs for derivative target words and
inflectional words was also found to be significant, though the difference between base word condition C1 and inflectional word condition C2 was not significant. The RT for identification of base words in general was shorter than the RT for inflectional words, but the difference was not significant. It may be noted that the mean word length difference between these two conditions was however significant. On the other hand, the inflectional word condition and derivational word condition did not differ on mean word length; but there was a significant difference between the conditions on RT. Thus, one may infer that parafoveal preview benefit was there for identifying words under these conditions though derivational words seem to be processed differently. We do not know whether seemingly more similarities between the base words (C1) and inflectional words (C2) in terms of semantics and orthographic features had an effect on the results obtained. Though Urdu has rich derivational morphology and word formation rules are similar to Hebrew and Arabic, especially for Arabic loanwords in Urdu, findings of the study should be treated cautiously. More controlled studies may help clear the issues discussed in the present study.

The results of the above experiment were not clear. This may be because all the three conditions, i.e. the base word, extension and derivatives were all morphologically related and we could not get a clear picture regarding
parafoveal preview benefit. Hence, we planned another experiment by replacing the extension (inflection) condition with an orthographic control. Also, we planned to have another experimental condition as a base line for the said stimuli. This experimental set had no presentation of the tri-consonantal root in the parafovea. The following experiment tested the preview benefit in comparison to no preview condition with a base word, a morphologically related word and an orthographic control to analyse whether the presentation of root letters in the parafovea facilitated word recognition in the fovea for morphologically related stimuli.

Note: We had to change the paradigm of this study from an invisible window paradigm using an eye tracker to e-prime as many attempts to program the study in presentation software and connecting it to the eye-tracker did not work. Even the assistance of Mr. Thorsten, an employee for SMI in Germany could not resolve the problem. Hence we had to change the paradigm.
**Experiment 4**

**Parafoveal Preview Benefit in Urdu Word Recognition**

**Introduction**

Reading takes place when a word is fixated on the foveal region and information from the parafovea seems to aid reading (Rayner et al., 1998). However, the information gained from the parafovea to aid reading depends upon the linguistic structure of a language. Research provides evidence that parafoveal preview benefit depends on, the phonological, orthographic and morphological structure of a language (Schotter, Angele, & Rayner, 2012). In languages like English, research shows that presentation of initial letters in the parafovea (phonological and orthographic features) aids reading, while, it is presentation of triconsonantal root in the parafovea aids morphological processing during lexical access in fovea in languages like Hebrew or Arabic (R Bertram, 2011).

Therefore, it is safe to conclude that stem based morphologies do not aid word recognition parafoveally while root based morphologies do. The reason seems to be in the process of derivations occurring in the respective languages. Indo-European languages follow stem-based morphology where the root letters first form a word called the stem or base and from this stem all the derivations occur resulting in semantic
opacity between the root and derivations. In case of Semitic languages, with root and pattern morphology, the words are derived directly from the root letters where root letters carry the core meaning and words derived from the said roots are usually semantically transparent, and this is the reason why presentation of root letters in the parafovea seems to aid word recognition in Hebrew (Deutsch et al., 2000) while the same is not seen in English.

Furthermore, even in morphologically rich language like Finnish (Bertram, 2011) one fails to see morphological preview benefit while another morphologically rich language like Hebrew (Deutsch et al., 2000) shows robust parafoveal preview benefit. Hence, the difference in results has been attributed to the differences in morphological structure than morphological productivity in the two languages (Kambe, 2004). The question of interest here is whether the differences in processes of derivations in root morphologies as compared to stem-based morphologies results in morphological preview benefit?

Consequently, derivations in root based morphologies are formed from the root and hence are semantically transparent and that readers of Semitic languages are tuned to identify words through their roots and thus learn to identify words through its root during the process of reading (Katz & Frost, 1992). In contrast, derivations in stem-based morphologies
are formed from the initial base/stem resulting in ambiguous semantic relationship between the stem and the derived words and hence readers in these morphologies are tuned to identify the syllable or initial letters during reading (Boudelaa, 2014). Therefore, it seems that morphological preview benefit, aids reading in Semitic languages and phonological / orthographic preview benefit, aids word recognition in European languages. The objective of this paper is to see if morphological preview benefit is observed in Urdu, i.e. the presentation of the root in the parafovea aids or limits word recognition in the fovea in case of Urdu. It is interesting to note that Urdu, an Indo-European language, stands a good chance to understand the underlying cognitive processes and its relation to morphological structure because Urdu morphology is an amalgamation of both Semitic and European languages.

**The Case of Urdu**

Urdu, an Indo-European language, seems to be sandwiched between Indo-European and Semitic morphology. It holds similarities in linguistic roots, grammar, lexicon and phonology with the former and orthography, non-concatenative feature, tri-consonantal root, lexicon, word formation and directionality with the latter (Rao, 2010). It exhibits Indic morphology for words of Indic origin while root morphology for Arabic loanwords in Urdu. It is not clear if the Arabic loanwords with the tri-
consonantal root that enter Urdu via Persian carry the salient features of root morphology of Arabic. Furthermore, Arabic loanwords in Urdu are borrowed as individual words or as a whole family of words from the same root (Khan, 2014). During the process of borrowing, semantics are also borrowed along with the whole family of words and contrastingly there are some loanwords that show semantic changes in other lexical borrowings. Furthermore, Arabic loanwords in Urdu vocabulary follow the source language and are used in the original form. However, these words show semantic changes also (Khan, 2014).

Ex. 1: Arabic tri-consonantal root کت‌ب (kitab) borrows all words derived through the root in Arabic into the Urdu lexicon—کتاب (kitab), مکت‌ب (maktab), کتاب (katib), کتاب (kutub), کتبا (katba) all are semantically related referring to writing as a core meaning which is evident in the root when in Arabic and the same rule is also evident in Urdu.

Ex. 2. Arabic words that bring about semantic change when they enter Urdu – قرار (qaraar) in Arabic means ‘decision’ while in Urdu it means ‘to rest or peace’
Studies on morphological structure and its role in word recognition in Urdu have hardly been attempted. The present paper plans to experiment on the stand Urdu morphology takes in word recognition. The main goal of this paper is to see if morphology plays a role in parafoveal processing in word recognition. The ambiguity and little research in the field of Urdu morphology make it interesting to know the impact of amalgamation of Urdu morphology and parafoveal effect in word recognition processes. To understand parafoveal processes, we highlight a few studies in the area of phonological, orthographic, morphological and semantic parafoveal processing in a couple of languages.
Research in parafoveal preview by (Bouma, 1973) showed naming of isolated letters, letters within words and complete words presented for 100ms at different eccentricities in the parafovea aided in accessing a word’s phonology. Experiments by Rayner et al., (1998) prove that information is obtained and used from the parafovea. Furthermore, studies using boundary paradigm revealed that phonological and orthographic information is obtained parafoveally and integrated with subsequent foveal information (Balota & Rayner, 1983; Handerson et al., 1995; Rayner, 1978; Rayner et al., 1980), that orthographic information is not based purely on visual similarity and found no evidence of semantic information being obtained parafoveally. Additionally, studies in phonological preview benefit showed, readers using phonological information to guide processing of a word that would be subsequently fixated (Ashby & Rayner, 2004; Ashby, Treiman, Kessler, & Rayner, 2006; Chace, Rayner, & Well, 2005; Rayner, Sereno, Lesch, & Pollatsek, 1995; Tsai et al., 2004). This was specifically true when a parafoveal preview was related, i.e. when preview rhymed phonologically, the results showed larger preview benefit (Chace et al., 2005) in French (Millet & Sparrow, 2004), English (Ashby et al., 2006), and even Chinese (Tsai et al., 2004). Furthermore, previews containing phonologically regular initial trigrams lead to larger preview benefit than irregular ones.
(Handerson et al., 1995) and similar initial syllable structure provided better preview benefit (Ashby & Rayner, 2004).

However, studies on orthographic processing showed words being processed orthographically even though the pairs (prime-target) differ in the degree of phonological overlap. The authors showed no preview benefit when prime-target pairs were matched for orthographic shape and benefit was higher when they shared the same initial letter irrespective of the shape and concluded that orthographically related parafoveal preview yields a strong preview benefit (Balota, Pollatsek, & Rayner, 1985; Briihl & Inhoff, 1995; Drieghe, Rayner, & Pollatsek, 2005; Lima & Inhoff, 1985; White, Johnson, Liversedge, & Rayner, 2008).

As regard to morphological processing, studies reveal that though morphology plays an important role in foveal processing, researchers found mixed evidence for parafoveal processing. While no evidence for parafoveal preview benefit was found in English (Juhasz, Pollatsek, Hyona, Drieghe, & Rayner, 2009; Kambe, 2004; Lima, 1987) and Finnish (Bertram & Hyona, 2007) for words and compound words (Inhoff, 1989; Juhasz et al., 2009), robust evidence was found in Hebrew (Deutsch, Frost, Pelleg, Pollatsek, & Rayner, 2003; Deutsch, Frost, Pollatsek, & Rayner, 2000, 2005). Thus, the above data indicated that morphological information is not processed parafoveally in English and Finnish with a
stem-based morphology (Bertram & Hyona, 2007) while the same is not true for Hebrew, a root-based morphology. The difference in results in English and Finnish in comparison to Hebrew has been attributed to the differences in the morphological structure of the respective languages.

A better explanation for the differences in morphological processing in the parafovea may be because words in English or Finnish are concatenated while non-concatenated in Hebrew where there is no spatial separation (Schotter et al., 2012). In addition, root letters carry the core meaning in Hebrew while it is not so in English or Finnish. Also, morphological constituents are separated and processed in Hebrew while it is not so in the English and Finnish. Furthermore, the position of the constituent letters in the root or word pattern in Hebrew is not fixed and hence the phonological or orthographic structure of the word does not reveal transparency with regard to morphology as against stem-based morphology in languages like English or Finnish. In addition to Hebrew studies, studies in Chinese (Yen, Tsai, Tzeng, & Hung, 2008) found larger preview benefit for morphologically identical prime-target pairs than orthographic pairs and (Yang, 2010) obtained the same for even bimorphemic Chinese compound words. The similarities in Chinese studies with that of Hebrew may be attributed to the differences in the character the morpheme that gets embedded in the word and also that
even two-character words seem to be processed in parallel by default owing to the grain size of Chinese characters and the possibility of it being effective in the foveal region.

Nevertheless, in case of Semantic preview benefit, studies show no effect for English and Finnish (Altarriba, Kambe, Pollatsek, & Rayner, 2001; Hyona & Haikio, 2005; Rayner & Duffy, 1986) while readers of German and Chinese showed preview benefit (Hohenstein, Laubrock, & Kliegl, 2010; Pollatsek, Hyona, & Bertram, 2000; Yang, Wang, Xu, & Rayner, 2009). The reason for little evidence for parafoveal semantic processing seems to be attributed to the trade-offs between orthographic and semantic information that nullifies the potential benefit effects and that strong relationship between semantics and orthography are important (Yen et al., 2009).

With the above review one can understand that parafoveal information can disrupt, limit or facilitate subsequent foveal processing. The objective of this paper was to study the dynamic linguistic features of Urdu and to see whether the borrowed tri-consonantal root of Arabic aided word recognition in Urdu.

We experiment to see if the borrowing of the tri-consonantal root from Arabic morphology also borrows the concept of root carrying the core meaning? This is intriguing because some Arabic loanwords in Urdu
continue to have semantic transparency between the root and derivations to a great extent while others don’t. It is important to note that the position of letters in the tri-consonantal root is also interleaved as in Arabic morphology. The question of interest is whether the root letters facilitate word recognition when presented in the parafovea and does semantic transparency play any role. The result may throw light on the process of word formations in Urdu i.e. whether the root first forms a stem and then all derivations follow as believed in stem-based morphology or is it root-based? If Arabic loan words are used in its original form in Urdu then the parafoveal preview benefit seen in Arabic due to root facilitation should also facilitate word recognition in Urdu. Contrastingly, we could believe that Urdu morphemes are nativized at the root level itself to form bases which branch out derivations and result in semantic opacity and hence should mime results from Indo-European language.

Urdu morphology shows concatenative features as seen in Indo-European languages and non-concatenative feature of Semitic language. It borrows lexicon, tri-consonantal root, orthography and semantics from Arabic while it exhibits grammar, syntax, semantics, and is based on linguistic structure of Hindi. This amalgamation has led to a complex and rich morphology. We need to know if morphological processing in Urdu
follows stem-based approach as in English/Finnish or root-based as in Hebrew/Arabic. We hypothesize that if Urdu morphology borrows the concept of core meaning in the root seen in Arabic and Hebrew to facilitate word recognition from the parafoveal preview especially for Arabic loanwords in Urdu, or the borrowing stops at the tri-consonantal root itself. In other words, is the borrowing limited to surface level? If this is true then we should not expect a preview benefit as seen in Hebrew. Conversely, we assume that Urdu morphology limits itself to borrowing of superficial features like orthography, basic semantics and tri-consonantal root and undergoes nativization to suit stem-based morphology. And this may be the reason why there was no priming effect at 80ms in Urdu as against Arabic (Rao, 2010). The results should give us a clear picture on probabilities of facilitation of tri-consonantal root in Urdu word recognition.

**Participants**

Thirty Undergraduate students between the age group/range of 20-25 years, who studied Urdu as their first language throughout their education and whose mother tongue was Urdu participated in the study. They were paid for their participation. Every participant had normal/corrected vision and normal hearing.
Stimulus Material

Two experimental sets were constructed. Each set had the same set of words as stimuli. The first experimental set had presentation of stimuli without a preview and the second experimental set had presentation of stimuli with a preview of root letters that form the target words. Each stimuli set had 40 Arabic loan words in each condition. In condition 1 target word formed the base word from the root, condition 2 target words were morphologically related to the preview and condition 3 target word that were orthographically similar to the root letters but not form words from the root letters used as primes in the parafovea. A total of 120 words were chosen for three conditions for each experiment. Word length was 3 to 6 letters in length. Word length of target words in condition 1 was 3-4 letters and condition 2 and 3 was 4-6 letters. The root letters that form all the target words across conditions were of 3 letters each, meaningless and not pronounceable. All the 120 words in the stimuli were Arabic loanwords in Urdu and were formed from the tri-consonantal root. Stimuli words were a mixture of semantically opaque and transparent in respect to the root letters.
Table 1: Stimuli type for three conditions used in the experiment.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Preview Root</th>
<th>Target Word</th>
<th>Transliteration</th>
<th>Meaning</th>
<th>Arabic Word</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 - Base words</td>
<td></td>
<td></td>
<td>Kitab</td>
<td>Book</td>
<td>كتاب</td>
</tr>
<tr>
<td>C2 - morphologically related</td>
<td></td>
<td></td>
<td>Maktab</td>
<td>School</td>
<td>مكتبة</td>
</tr>
<tr>
<td>C3 - orthographic control</td>
<td></td>
<td></td>
<td>Kabab</td>
<td>Meat</td>
<td>كتاب</td>
</tr>
</tbody>
</table>

Fig2 - Stimuli type for three conditions used in the experiment.

**Procedure**

Stimuli were presented using E-Prime experimental software in a simple priming parafoveal preview benefit task. Each trial started with a “+” sign at the centre of the screen on which the subjects were asked to fixate. This display lasted for 500ms and was followed by a ‘preview screen’ which consisted of a “+” sign in the centre and a preview stimuli located to the left of the plus sign. The distance between the “+” sign and the first character of the preview stimulus was about 30 visual angle. The preview stimulus was timed at 50ms. The ‘preview screen’ was replaced by a ‘target screen’ with the target word appearing at the centre of the screen and remained on the screen until the participants responded. The last ‘ready screen’ would allow the participants to go to the next trial. Participants were instructed to look at the “+” sign and recognize the word that was displayed as fast as they could and press space bar. When the ‘ready screen’ was displayed they were asked to write the word they recognized. This was done to ensure accuracy. Response time from the
onset of the target word until the participants responded was considered as dependent variable.

Participants were presented with 10 practice trials before the experimental trials started. Each participant was presented with 120 trials for each experimental set. All trials were randomized ensuring no trial repeated.

Fig 3- Display of stimuli

**Data Analysis**

Correct RTs in the three experimental conditions from both the experimental sets were averaged across subjects. RTs that were outside a range of 3 standard deviations from the mean were curtailed. The effect of outliers was minimized by establishing cut-offs 3 standard deviation units above and below the mean for each participant. Trials in which an error occurred were discarded.
Results

We examined the results to investigate parafoveal preview benefit effect in a 2x3 factorial analysis with preview & no preview as factor 1 (F1) X 3 conditions as factor 2 (F2) in repeated measures analysis of variance (ANOVA). The analysis revealed no significant effect for F1 (F = 5.6; \( p = 0.23 \)) and significant effect for F2 (F = 8.9; \( p = 0.001 \)) and no significant interaction effect (F = 5.1’ \( p = 0.14 \)). A post hoc analysis (Bonferroni) for F2 revealed significant differences between C1-C2 and C1-C3 (\( p = 0.001; p = 0.006 \)) and no significant effect between C2-C3 (\( p = 0.479 \)).

Table1- Subject-wise average mean and SD for (P) preview and No Preview (NP) for three conditions (C1, C2, and C3)

<table>
<thead>
<tr>
<th></th>
<th>Full</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>814.06</td>
<td>1063.57</td>
<td>554.05</td>
<td>981.80</td>
</tr>
<tr>
<td>SD</td>
<td>376.53</td>
<td>538.08</td>
<td>476.61</td>
<td>573.46</td>
</tr>
<tr>
<td>NP</td>
<td>853.62</td>
<td>895.73</td>
<td>934.83</td>
<td>573.46</td>
</tr>
</tbody>
</table>

Paired t-test between prime and no prime for conditions showed no significant differences between base word and orthographic control conditions (C1- \( t = 9.49, p = 0.35 \); C3- \( t = 0.811, p = 0.42 \)) while it showed significant differences in the morphologically related condition (C2- \( t = 5.45, p = 0.00 \)). Additionally, the preview benefit seen in the
morphologically related condition seemed to inhibit facilitation of the preview of root letters and participants took more time to recognize words in the preview condition as compared to the no-preview one. We questioned probabilities of semantics to be the reason and hence we went in for additional analysis.

![Fig4: Distribution of response time for preview and no preview across conditions.](image)

(Factor 1-Preview -No-Preview; and Factor2- 1- Base words, 2- morphologically related, 3- orthographic control)

**Additional Analysis**

The stimuli were separated for semantic transparency. 22 stimuli were semantically opaque and 16 were semantically transparent to the root letters presented in the parafovea, 2 stimuli were ambiguous and were discarded from analysis. The repeated measures ANOVA revealed significantly different effect for semantically opaque stimuli for factor 1.
(F1 - preview- No-Preview) and factor 2 (F2 - Conditions) (F1- F= 7.4, \( p = 0.001 \); F2- F= 9.6, \( p = 0.00 \)) was observed while for semantically transparent stimuli preview yielded no significant effect for preview benefit and significant differences were seen for conditions (F1 - F= 1.7, \( p = 0.19 \); F2 - F= 5.8, \( p = 0.007 \)). Interestingly, we saw an interaction effect between F1 and F2 (F= 2.9, \( p = 0.06 \)). Post hoc analysis (Bonferroni) for semantically opaque stimuli revealed significant differences between all conditions (C1-C2 – \( p = 0.00 \), C1-C3 – \( p = 0.04 \), C2-C3 – \( p = 0.03 \)) while the same was not seen in semantically transparent stimuli (C1-C2 – \( p = 0.01 \), C1-C3 – \( p = 0.008 \), C2-C3 – \( p = 0.34 \)).

Table 2 – Average mean And SD for semantically opaque and transparent stimuli across conditions

<table>
<thead>
<tr>
<th></th>
<th>Semantically Opaque Stimuli</th>
<th>Semantically Transparent Stimuli</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C1</td>
<td>C2</td>
</tr>
<tr>
<td>Mean</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>P</td>
<td>812.80</td>
<td>431.47</td>
</tr>
<tr>
<td>NP</td>
<td>867.72</td>
<td>434.17</td>
</tr>
</tbody>
</table>

Paired t-test between preview and no-preview factor for semantically opaque and transparent stimuli showed significantly different effect in the morphological condition only (C1- \( t = 1.29, p = 0.20 \); C2 - \( t = 4.14, p = 0.00 \); C3 - \( t = 1.52, p = 0.13 \)) for semantically opaque stimuli and (C1 - \( t = 1.49, p = 0.17 \)) for semantically transparent stimuli.
= .55, \( p = 0.58 \); \( C2 - t = 2.88, \ p = 0.007 \); \( C3 - t = 0.28, \ p = 0.78 \) semantically transparent stimuli.

Fig 5: Distribution of response time for semantically opaque stimuli across conditions (1-C1, 2- C2, 3-C3)

Fig 6: Distribution of response time for semantically transparent stimuli across conditions (1- C1, 2- C2, 3-C3)
Discussion

Research in many languages have examined parafoveal processing during reading words and sentences using paradigms like masked priming, boundary paradigm and ERPs. Authors studying English and Finnish found no preview benefit (Bertram & Hyona, 2007; Juhasz, 2008; Kambe, 2004; Lima, 1987) while a reliable preview benefit being observed for Chinese (Yen et al., 2008) and Hebrew (Deutsch et al., 2000, 2005). Research confirms that, readers access low level information like partial word, word length and phonological information from the parafovea and integrate it with further information acquired when fixating the target word for most of the alphabetic languages. High level information may be extracted from the parafovea during lexical access through phonology, orthography, morphology and semantics in languages especially in Chinese and Hebrew (Yang, 2010). Hence, preview benefit depends on the specific linguistic feature of a language.

The main objective of this experiment was to see the role tri-consonantal root borrowed from Arabic for loanwords in Urdu carries the core meaning as in Arabic to facilitate word recognition in the parafovea. We also wanted to see effect of semantics in Arabic loan words. The presentation of the triconsonantal root letters did not facilitate word recognition in the fovea. This shows that the facilitatory feature seen in
Hebrew is not true for Urdu. However, we did observe differential processing strategies to be evident across conditions. More intriguing is that the analysis of preview benefit using a paired $t$ test revealed that a preview benefit was observed only in the morphologically related stimuli and that it seemed more inhibitory than facilitatory. Hence, we wanted to see if semantics played a role.

Interestingly, we found preview benefit in the semantically opaque stimuli and again in the morphologically related condition only while no preview benefit was observed in the semantically transparent set. Again, paired $t$ test revealed significant differences for morphologically related stimuli only for both semantically opaque and semantically transparent stimuli.

The above analysis clearly presents the effect of triconsonantal root in the parafovea did not affect or benefit semantically transparent stimuli but it did affect semantically opaque stimuli and more so for the morphologically related stimuli. Unpredictably, the affect was inhibitory than facilitatory. This is again a new finding in case of Urdu. Studies in morphological preview benefit are observed to be either facilitatory as in Hebrew or not as in English and Finnish. Our study reveals morphological preview benefit to be inhibitory only for morphologically related stimuli.
The overall results reveal that in case of Arabic loanwords in Urdu, morphology acts as a detrimental factor when the root letters were presented in the parafovea.

Unpredictably, we saw inhibitory preview benefit only in morphologically related condition irrespective of semantics. The preview benefit found across conditions was purely due to morphological factors and effect of semantics seemed to be ruled out.

It is clear that the concept of root letters carrying the core meaning seen in Arabic/Hebrew has not been borrowed in Urdu. Urdu morphology seems to be more stem-based as in Indo-European languages and that the borrowing of tri-consonantal root, orthography, semantics and the like from Semitic language are only superficial. We provide evidence that even loanwords of Arabic seem to undergo nativization at the root level to suit Indic-based morphology and hence parafoveal information of root letters not only inhibits but acts as a detrimental factor during word recognition. Further research using words of Indic origin or presentation of the initial letters in the parafovea would be beneficial to know if orthography played any facilitatory role.

With the above experiments giving a clear picture on the inhibitory role of morphological preview benefit during word recognition we designed the last experiment on word type. This experiment focused on the
processing of Arabic loanwords in a simple reading task. We now wanted to see if the triconsonantal root that forms the basis of word formations in Urdu for Arabic loanwords in Urdu facilitated reading as compared to words that were formed from a stem.
Experiment 5

Effect of Derivatives of Different Root Words in Lexical Processing

Introduction

Eye movement studies have shown morphological decomposition during lexical processing. Morphological structure of a language normally contains a root and one or more affixes (Iacobani, 2008), where root is referred to as a lexical content morpheme that cannot be further analysed and a stem is referred to as a root morpheme with affixes. Additionally, researchers have understood a great deal about how an individual acquires information, representation and integration of printed text in the course of comprehension (Rayner, 1978; Rayner et al., 1998) and that morphological decomposition depends on the lexical category during lexical access (Hyona & Pollatsek, 2004).

The first attempt on morphological decomposition of two morpheme words was attempted by Hyona & Pollatsek (1998) who showed that frequency of constituent morphemes influenced morphological decomposition (Pollatsek, Hyona, et al., 2000). In addition, eye movement studies on morphological decomposition have observed infrequent words (Just & Carpenter, 1980; Rayner, 1997), phonologically ambiguous words (Carpenter & Daneman, 1981), words differing in spelling and same pronunciation (Folk, 1999; Jared, Levy, & Rayner,

Furthermore, studies on morphological decomposition (Burani, Salmaso, & Caramazza, 1984), Semantic transparency (Andrews, Miller, & Rayner, 2004; Juhasz, Starr, Inhoff, & Placke, 2003), word recognition (Kempley & Morton, 1982; Murrell & Morton, 1974) lexical decision (Taft, 1979; Taft & Forster, 1975) word production (Mackay, 1978) speech errors in normal (Garrett, 1980), aphasic/dyslexics (Caramazza & Berndt, in press) and morphological level (Vannest & Boland, 1999) conclude lexical status, morphological level and morphological structure of a language play an important role in lexical access and word recognition.

Additionally, research in compound word processing enables one to understand the nature of lexical storage in the mental lexicon and if compound words are accessed as a whole or is it lexically decomposed into its component constituents. It also focuses on the phenomenon in which compound words are decomposed (Andrews & Davis, 1999; Hudson & Buis, 1995; Libben, 1994; Taft, 1981; Taft & Forster, 1975). Hence, research in this field has concluded that there could be interplay
between morphological decomposition and whole word recognition. Also, morphological decomposition is based on the influences of frequency, word length, semantic transparency, morphological structure and morphological class (McQueen & Cutler, 1998). In this light, Libben (2003) postulates a flexible theory of lexical processing from his findings that opaque compounds activate whole word meaning while transparent compounds activate the constituent meaning. More research supporting this concept shows that individual constituents are morphologically decomposed (Fiorentino & Poeppel, 2007; Hyona & Pollatsek, 1998; Juhasz, Starr, Inhoff, & Placke, 2003), transparent compounds are semantically accessed (Sandra, 1990; Zwitserlood, 1994) and compounds may have unitary lexical representation (Van Jaarsveld & Rattink, 1988; Zhou & Marslen-Wilson, 1994). Furthermore, ERP study on compounds with semantically varied psycholinguistic features suggests a dynamic and flexible mechanism supporting lexical processing of compound words (MacGregor & Shtyrov, 2013).

With regard to morphological decomposition of compound word into constituent morphemes, beginning lexeme effect was evident in first fixation duration (Bertram & Hyona, 2003; Pollatsek, Bertram, & Hyona, 2000) in Finnish language but Andrews, Miller, & Rayner, (2004) and
others did not find the same effect in English (Juhasz, 2007; Juhasz et al., 2003).

Therefore, reading models postulate that words, words with affixation, morphologically transparent/opaque words are all accessed by morphological decomposition into its constituent morphemes or by stripping off their affixes (Taft & Forster, 1975) while whole words are accessed as a single non-composed unit. However, the difference regarding inferences in different languages may be attributed to variation in morphological structure and productivity of that language (Plaut & Gonnerman, 2000; Rueckl & Raveh, 1999).

From the above studies, one can understand that characteristic linguistic structure, morphological level, lexical status, lexical category, morphological productivity and complexity of a language are important determiners in the way words are accessed, segmented or decomposed during lexical access. The processing strategies in the above studies mainly deal with European and Semitic languages. We find only a couple of priming studies in lexical access on Hindi in comparison to Urdu (Rao, Vaid, Srinivasan, & Chen, 2011).

Urdu, an Indo-European language, is an amalgamation of Arabic, Persian, English, and Sanskrit. It would be interesting to investigate the similarities and differences in processing strategies during word
recognition in Urdu in comparison to results in European languages on one hand and Semitic language on the other.

Morphological formations in Urdu include analytic, synthetic and agglutinative elements (Rao, 2011). The concatenative and non-concatenative nature of Urdu morphology results in heterogeneity during word formation. Nouns and adjectives are marked for number, gender and case. Pronouns are marked for case only and verbs are marked for mood, tense and aspect in addition to having specific inflections for gender and number (Cardona & Jain, 2003; Kachru, 2006; Mathur, 2004; Singh & Agnihotri, 1997). The combined effect of noun declension, verb marking, adjective marking and post positions make Urdu morphology a very rich, complex, diverse but highly consistent morphology (Rao, 2011).

The present study addresses four important issues with regard to processes involved during lexical processing in Urdu. First, it plans to investigate whether the tri-consonantal root borrowed from Arabic continue to facilitate lexical access in Urdu as in Arabic. If so, the underlying process during lexical access is expected to be similar to that of Arabic. We expect to see processing differences between words with tri-consonantal root and words with no specific root. The results may aid to the extensive research that concludes lexical status and morphological structure to play a critical role in lexical access.
Studies by Lima (1987), Taft & Forster, (1975) and others postulate affixes being stripped off their stems before lexical access. Furthermore, studies in Finish compound words observed length of the compound word to modulate compound words recognition (Bertram & Hyona, 2003). The second objective of the paper was to see if lexical processing of Persian prefixed Arabic root words were processed similarly as per Taft and Forster’s (1975) model of prefix stripping and processing differences of compound words on a preliminary level. We expected to see differential processing for different types of words. In other words we hypothesized differences in processing of whole words, prefixed and compound words.

Finally, we wanted to see what feature of the morpheme aids in early word recognition and differences in processing in a later stage. Hence we took first fixation duration as an index to early facilitation in lexical access and Dwell time as a late measure to see the differences in processing of different types of words.

**Measures**

Studies have concluded that results pertaining to processing of words are task dependent. In other words, tasks like lexical decision or word naming differ in how words are identified in isolation as these tasks impose a secondary task that may influence recognition as compared to normal reading condition. Also, readers gain prior information of the
upcoming word from the parafovea which aids in recognition (Rayner, 1998, for review). One way to limit such discrepancies is to frame neutral sentences with target word in a way where context is not revealed, while recording eye movement measures. This paradigm gives the researcher an insight on how words or compound words are accessed in a time course in the most natural settings during reading a text.

Paradigm

We adopted a simple sentence reading paradigm, wherein participants were instructed to read the sentences while eye movement measures were recorded online.

Participants

30 graduate students, in the age group of 25-30 years participated in the experiment. Their mother tongue was Urdu. Elementary education was in Urdu medium and Urdu was their first language of study in college. Informed consent was taken. All participants had normal vision and hearing. Participants were paid for their participation.

Stimuli Material

The words were chosen from Secondary school text books, newspapers and from “A Dictionary of Arabic Derivatives in Urdu” by Koul, M.K. These words were measured for frequency on a 7 point scale with 1 as ‘highest in frequency’ and 0 as ‘never heard’. Length of each word was 3
to 6 letters. A total of 500 words were listed and were marked by 35 professionals. They did not participate in the experiment and were oblivious of the purpose of marking. They were instructed to mark the words according to the frequency of occurrence of the word in print. 25 high frequency words were selected for the experiment after evaluation. Finally, a set of 100 high frequency words were selected for each experimental condition (25 x 4 = 100).

We analyzed effect of word length and frequency across conditions. The average means of word length and frequency for all the four conditions are given in table1.

Table1- Mean for phoneme length, word length and frequency for all the conditions.

<table>
<thead>
<tr>
<th></th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Word length</strong></td>
<td>3.6</td>
<td>5.56</td>
<td>4.05</td>
<td>6.88</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>29.52</td>
<td>27.52</td>
<td>30.12</td>
<td>26.56</td>
</tr>
</tbody>
</table>

A one-way ANOVA revealed significant effect of word length (F = 73.63, p = 0.00) but no significant differences in frequency (F = 2.37, p = 0.075) was observed across conditions. Post hoc analysis (Bonferroni) for word length revealed significant differences between conditions.
except between C1-C3 (C1-C2 = 0.00, C1-C3 = 0.21, C1-C4 = 0.00, C2-C3 = 0.00, C2-C4 = 0.00 and C3-C4 = 0.00); Phoneme length was significant between all conditions (C1-C2 = 0.00, C1-C3 = 0.01, C1-C4 = 0.00, C2-C3 = 0.002, C2-C4 = 0.00 and C3-C4 = 0.00); and frequency showed no significant differences across conditions(C1-C2 = 1, C1-C3 = 1, C1-C4 = 0.33, C2-C3 = 0.55, C2-C4 = 1 and C3-C4 = 0.13).

Method

The experiment had the following 4 conditions

Condition1- 25 words with no specific root of Persian origin. Ex bagh

Condition2- 25 words with Persian prefixes with Arabic root words. Ex -ba izzat

Condition 3- 25 words with tri-consonantal Arabic root of Arabic origin. Ex- izzat

Condition 4- 25 compound words with a mixture of Arabic and Persian words as the first constituent. All the words were from condition 1 and 3 as first or second constituent. Ex. Kitab ghar or khush aqlaq

Example of the sentence formation with the target word appearing in the third position:
there are many libraries in Delhi (Dehli mein kitabghar bahut hain)

Each word was framed into a sentence in such a way that the target word always appeared in the third position of the sentence, thereby giving no clue of the context. For precision, there was a break after half of the trials were over and the experiment continued after successful re-calibration and validation.

**Design**

The Visual display had a “+” sign on the right of the screen for 700ms and the sentence commenced. The sentences across condition were randomized. Each trial lasted for about 5000ms. A SMI eye tracker of 1250Hz resolution was used to collect data. Participants were instructed to read the sentence and press the space bar to go to the next trial.

![Stimuli Display](Fig1.png)

**Procedure**

After successful calibration, the experimental trial began with a fixation cross at the right of the screen followed by the presentation of the
stimulus. Each experimental sentence lasted for about 5secs and each experimental session lasted for about 20-30 minutes. 10 experimental sentences were selected as practice trials and appeared at the beginning of the experiment in order to help participants familiarize with the experiment.

**Data Cleaning**

AOI’s for each word across conditions were marked. The AOI’s marked were not of the same size as the words differed in their length across conditions. For example a word like *wafa* بَاْ with a small sized AOI and *kitab ghar* کتاب گھر with a comparatively large AOI was marked only around the word boundaries. All fixations outside the marked AOI were not considered for analysis. First fixation duration less than 30 ms were excluded from analysis. Eye movement measures chosen for analysis were First Fixation Duration and Dwell Time. First Fixation duration is the number of first fixations on the AOI and Dwell Time measure is the sum of all fixations and saccades that hit the AOI starting at the moment the AOI is fixated and ends at the moment the last fixation on the AOI ends for each visit of the AOI.
Results

We subjected the averaged means for conditions for statistical analysis. The subject-wise and average mean and SD for First Fixation Duration and Dwell Time for all the four conditions is given in table 2.

Table 2- Subject-wise Mean and SD for conditions for First Fixation Duration and Dwell Time.

<table>
<thead>
<tr>
<th></th>
<th>First Fixation Duration</th>
<th>Dwell Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td><strong>C1</strong></td>
<td>199.991</td>
<td>45.73344</td>
</tr>
<tr>
<td><strong>C2</strong></td>
<td>220.5174</td>
<td>53.8867</td>
</tr>
<tr>
<td><strong>C3</strong></td>
<td>208.066</td>
<td>40.75028</td>
</tr>
<tr>
<td><strong>C4</strong></td>
<td>198.3968</td>
<td>53.73887</td>
</tr>
</tbody>
</table>

A repeated measure ANOVA revealed no significant differences in First Fixation Duration (FFD) across conditions. Post hoc analysis (Bonferroni) (C1-C2 - p = 0.117, C1-C3- p = 0.1, C1-C4 -p = 0.1, C2-C3- p = 0.67, C2-C4- p = 0.21 and C3-C4- p = 0.1). The results indicate that though word length was significant across conditions these features did not aid early in word recognition. It seems that the morphological complexity of a word is a more decisive factor than word length to effect early processing stages.
The next measure of interest was Dwell Time. The analysis revealed significant differences between all conditions except between C1-C3 (C1-C2 - $p = 0.00$, C1-C3- $p = 0.1$, C1-C4 -$p = 0.00$, C2-C3- $p = 0.00$, C2-C4- $p = 0.00$ and C3-C4- $p = 0.00$). The significant differences in processing the stimuli clearly shows the results are in lieu with previous research that words are processed differentially and that morphological complexity is again a decisive factor even in later stages of processing.

**Discussion**

Studies support the notion that morphological complexity of a language plays a significant role in lexical access. Also, morphological complexity of a word depends upon the process of word formation (affixation to the root, stems or by compounding). Additionally, the concatenative/non-concatenative feature affects morphological complexity of a language. Urdu evidences both the features of morphological complexity i.e. word formation processes and concatenation. Words are formed from the Arabic tri-consonantal root, the Persian stem, and Indic stems. Derivational affixes from Arabic, Persian and Indic origins contribute to the lexicon and words are also formed by compounding. Furthermore, Urdu borrows the property of non-concatenative feature of Arabic and Hebrew along with concatenative features of Indo-European language.
Thus, word formation becomes a morphologically complex process in Urdu.

Our expectations from this experiment, was to see significant differences in lexical processing for words with the Arabic tri-consonantal root formations as compared to the words with no specific root (Persian roots/stem). And secondly, we expected to see differences in processing across word type.

Fig2. First Fixation Duration for every 100ms from start of visual display sentence till end of sentence across conditions
The present experiment contrasts the root morpheme facilitation in Urdu in comparison to the facilitation in Hebrew. We did not find facilitatory feature of triconsonantal root in processing words with tri-consonantal root in comparison to words with no specific root. Though Urdu shares vocabulary, morphology, orthography and the non-concatenative features with Arabic, it seems that it does not borrow the salient feature of root facilitatory feature of carrying the core meaning of the word. This may be because most of the Arabic loan words in Urdu have entered via Persian where the tri-consonantal root undergoes changes first in Persian and then modification of the base and phonology in Urdu (Islam, 2010). Therefore, words in Urdu seem to be processed in the same way as in Indo-European languages, irrespective of the Arabic tri-consonantal root or without
specific root. Furthermore, representation of root morpheme at a distinct morphological level seen in Arabic seems to be unknown to Urdu.

Our second objective was to see significant differences in processing levels across word type. That is, whether whole words, prefixed words and compound words were processed differentially. We found significant differences in processing among word type and thereby report that typology of word effects lexical processing. This may hint us on differential processing of prefixed words following the Taft and Forster’s model of prefix stripping and morphological decomposition for compound words.

Furthermore, early processing effect across word type was not observed in first fixation duration. This may be because Urdu is a morphologically and visually complex language and hence more time is needed for lexical access.

We found significant differences across word type in Dwell time, a later processing measure. This suggests that Urdu being a morphologically and visually complex language needs more time for lexical access. The experiment showed significant processing differences between C1-C4 and C3- C4 predicts differences in processing whole words and compound words even though the stimuli in C4 were a mixture of words from C1 and C3 (12 words from C1 and 13 words from C3 were chosen.
to form compounds). Therefore, we assume that compound words thus formed may have been accessed both in whole-word form and in morphologically decomposed form depending upon the morphological structure of the compound word being accessed. We suggest that the compounds like kitabghar کتاب گھر may have adopted the whole-form where the first constituent is semantically transparent and compounds like ghair musalman غیر مسلمان may have been morphologically decomposed where the first constituent is semantically opaque during lexical access. Our results seem to be in line with the flexible theory postulated by Libben (2005) with regard to compound word processing. More research in compound word processing per say in Urdu is required.

To summarize, the present research suggest that words may be searched for the whole form in the mental lexicon irrespective of a specific root. In other words, the tri-consonantal root borrowed in Urdu from Arabic does not play a significant role in lexical access. Additionally, we also report differential processing among word type in the Dwell time, a late processing measure. Also, we did not observe significant differences in First fixation duration across word type signaling morphological
complexity have no effect in the early processing stage. The results need further investigation for more concrete assumptions.