

Reading Direction and Sentence Interpretation in Urdu–English Bilingual Readers

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Received: 4th January, 2026

Revised: 20th March, 2026

Accepted: 28th June, 2026

DOI:

<https://doi.org/10.69545/j65vn768>



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Abstract

Background: Reading direction is a fundamental characteristic of written language that influences visual attention, eye movement patterns, and cognitive processing during reading. Bilingual individuals who routinely read languages with opposite writing directions, such as Urdu (right-to-left) and English (left-to-right), provide a unique opportunity to investigate how script orientation affects sentence interpretation. Despite increasing interest in bilingual language processing, limited research has examined the influence of reading direction on comprehension and interpretation among Urdu–English bilingual readers.

Objective: To examine the effect of reading direction on sentence interpretation and reading performance among Urdu–English bilingual adults.

Methodology: A cross-sectional experimental study was conducted among 80 Urdu–English bilingual university students aged 18–30 years. Participants completed standardized sentence comprehension tasks presented in Urdu and English under controlled conditions. Reading time, comprehension accuracy, and response latency were recorded. Data were analyzed using paired-sample t-tests, repeated-measures ANOVA, and Pearson's correlation, with statistical significance set at $p < 0.05$.

Results: Participants demonstrated significantly faster reading speed in their dominant language while maintaining high comprehension accuracy in both languages. Response latency differed significantly between left-to-right and right-to-left sentence presentation, indicating that reading direction influenced sentence processing efficiency. Strong positive correlations were observed between language proficiency and comprehension accuracy in both reading directions.

Conclusion: Reading direction significantly influences sentence interpretation among Urdu–English bilingual readers. The findings suggest that bilingual readers flexibly adapt cognitive strategies according to script orientation, highlighting the interaction between orthographic systems and language processing. These findings have implications for bilingual education, psycholinguistics, and cognitive neuroscience.

Keywords Reading direction, bilingualism, Urdu, English, sentence processing, language comprehension, psycholinguistics, cross-linguistic research.

Introduction:

Reading is one of the most sophisticated cognitive activities performed by the human brain, requiring the rapid integration of visual perception, attention, memory, lexical retrieval, syntactic analysis, and semantic interpretation. During reading, the brain transforms visual symbols into meaningful linguistic representations through a series of coordinated cognitive processes. Sentence processing, in particular, involves recognizing individual words, determining grammatical relationships among them, integrating contextual information, and constructing coherent meaning. These processes occur within fractions of a second, highlighting the remarkable efficiency of the human language system.

Among the many factors influencing reading performance, the direction in which text is read represents a unique but often overlooked characteristic of written language. Orthographic direction determines the sequence of eye movements, allocation of visual attention, and spatial organization of information during reading. Most Indo-European languages, including English, are written from left to right (LTR), whereas languages such as Urdu, Arabic, Persian, and Hebrew follow a right-to-left (RTL) writing system. These contrasting orthographic conventions require readers to employ different visuospatial scanning strategies, potentially influencing the efficiency of language processing and sentence interpretation.

Research in cognitive psychology suggests that habitual reading direction shapes visual attention beyond language itself. Individuals accustomed to left-to-right scripts often demonstrate left-to-right scanning preferences during visual search, memory

retrieval, numerical reasoning, and picture perception. Conversely, readers of right-to-left languages frequently display reversed attentional biases. These findings indicate that reading direction may influence broader cognitive processes extending beyond literacy. However, the extent to which these attentional patterns affect sentence comprehension among bilingual readers remains an area of active investigation.

Sentence processing is influenced by multiple interacting factors, including word frequency, vocabulary knowledge, syntactic complexity, working memory capacity, contextual cues, and language proficiency. For bilingual individuals, additional cognitive demands arise because they must manage two linguistic systems simultaneously while inhibiting interference from the non-target language. Theories such as the Bilingual Interactive Activation Model propose that both languages remain partially active during reading, requiring continuous cognitive control to select appropriate lexical representations. Consequently, bilingual sentence processing provides an excellent framework for understanding how language-specific characteristics interact with general cognitive mechanisms.

Urdu–English bilinguals represent a particularly interesting population for examining the influence of reading direction on sentence interpretation. Urdu employs the Perso-Arabic Nastaliq script, which is written from right to left and is visually complex due to its cursive structure and context-dependent letter forms. English, by contrast, uses the Roman alphabet and follows a left-to-right orientation with relatively stable letter shapes. Individuals who regularly alternate between these

languages must repeatedly adjust eye movement direction, attentional orientation, and orthographic processing strategies. This continual switching provides a natural opportunity to examine cognitive flexibility during reading.

Previous research has shown that bilingual readers often develop enhanced executive control, attentional flexibility, and cognitive adaptability compared with monolingual readers. Regular management of two language systems has been associated with improvements in inhibitory control, task switching, and selective attention. These advantages may enable bilingual readers to efficiently accommodate differences in writing direction. However, whether such cognitive flexibility completely eliminates processing costs associated with switching between opposing orthographic systems remains uncertain.

Eye-tracking studies have demonstrated that reading direction influences fixation duration, saccadic movements, and parafoveal processing. Readers generally develop automatic eye movement patterns consistent with the writing system of their dominant language. When reading a language with an opposite orthographic orientation, these established patterns may require temporary adjustment, potentially increasing processing time and cognitive effort. Although neuroimaging research has identified overlapping neural networks involved in bilingual reading, behavioral investigations remain essential for understanding how these neural processes translate into observable reading performance.

Theoretical perspectives such as the Spatial Agency Bias Theory and embodied cognition further suggest that habitual reading direction influences mental representations of time, causality, and event sequencing. For example, left-to-right readers often conceptualize temporal progression from left to right, whereas right-to-left readers may exhibit the opposite pattern. These findings indicate that orthographic direction affects not only visual scanning but also higher-order cognitive organization. Investigating sentence interpretation among Urdu–English bilinguals may therefore provide valuable insights into how opposing writing systems interact with semantic and syntactic processing.

Educationally, understanding the cognitive consequences of reading direction is increasingly important in multilingual societies. Pakistan represents a linguistically diverse environment where English functions as the primary language of higher education, science, and professional communication, while Urdu serves as the national language and a major medium of everyday interaction. Students frequently transition between Urdu and English during academic activities, reading textbooks, completing examinations, and communicating in classroom settings. Knowledge of how reading direction influences comprehension may therefore inform instructional strategies, assessment design, and bilingual literacy programs.

Despite growing international interest in bilingual language processing, relatively few studies have specifically examined the behavioral effects of reading direction among Urdu–English bilingual adults. Existing research has largely focused on Arabic–English or Hebrew–English bilingual

populations, leaving an important gap concerning South Asian bilingual readers. Furthermore, many previous investigations have emphasized eye-tracking or neuroimaging techniques, whereas behavioral measures such as comprehension accuracy, reading speed, and response latency remain comparatively underexplored in Urdu-speaking populations.

Addressing this gap may contribute to both theoretical and practical understanding of bilingual cognition. From a theoretical perspective, examining how readers process sentences presented in opposite writing directions can enhance existing models of bilingual language processing, visual attention, and orthographic representation. From a practical perspective, findings may assist educators in developing instructional approaches that accommodate the cognitive demands associated with reading across different scripts.

The present study therefore aims to investigate the influence of reading direction on sentence interpretation among Urdu–English bilingual university students. Specifically, the study compares reading speed, comprehension accuracy, and response latency while participants process sentences in Urdu and English. Additionally, it explores the relationship between bilingual language proficiency and sentence-processing performance. By examining these factors, the study seeks to provide empirical evidence regarding the cognitive adaptations employed by bilingual readers when navigating two contrasting orthographic systems..

Methods:

A quantitative cross-sectional experimental study was conducted between February and April 2026 at a private university in Pakistan to investigate the influence of reading direction on sentence interpretation among Urdu–English bilingual readers. The study employed a within-subject design in which each participant completed sentence-processing tasks in both Urdu and English, allowing direct comparison of performance across the two orthographic systems while minimizing individual variability.

The study population comprised undergraduate and postgraduate students who were proficient in both Urdu and English. Participants were recruited using convenience sampling through departmental announcements and electronic invitations. Eligibility criteria included being between 18 and 30 years of age, having completed at least twelve years of formal education, and reporting regular use of both Urdu and English in academic or daily communication. Individuals with diagnosed neurological disorders, uncorrected visual impairments, reading disabilities, or a history of psychiatric illness affecting cognitive performance were excluded from participation.

Based on previous psycholinguistic studies examining bilingual sentence processing, a total sample of 80 participants was considered adequate to detect moderate differences in reading performance between languages while maintaining statistical power.

Data were collected in a quiet laboratory environment using a computer-based sentence comprehension task developed for the study. The experimental material consisted of forty grammatically correct sentences, including twenty Urdu sentences written in Nastaliq script and twenty English sentences written in Roman script. The two sets of sentences were matched as closely as possible for length, syntactic complexity, vocabulary frequency, and semantic content. Each sentence was followed by a multiple-choice comprehension question designed to assess accurate interpretation of sentence meaning.

Participants first completed a demographic questionnaire that collected information regarding age, gender, educational level, native language, age of acquisition of English, and self-reported language proficiency. Before beginning the experimental task, participants completed five practice trials to familiarize themselves with the testing procedure.

During the experiment, sentences were presented individually on a computer screen. Participants were instructed to read each sentence carefully and answer the corresponding comprehension question as quickly and accurately as possible. Reading time was automatically recorded from sentence presentation until the participant advanced to the comprehension question. Response latency was measured as the interval between presentation of the question and selection of the answer. Comprehension accuracy was calculated as

the percentage of correctly answered questions.

To reduce order effects, the presentation order of Urdu and English sentence blocks was counterbalanced across participants. Half of the participants completed the Urdu task first, while the remaining participants began with the English task. Short rest periods were provided between language blocks to minimize fatigue.

Data were analyzed using IBM SPSS Statistics version 27. Descriptive statistics including frequencies, percentages, means, and standard deviations were calculated for demographic characteristics and performance measures. Paired-sample *t*-tests compared reading speed, response latency, and comprehension accuracy between Urdu and English sentence-processing tasks. Repeated-measures analysis of variance (ANOVA) examined differences in performance across language conditions while controlling for order effects. Pearson's correlation coefficient assessed relationships between bilingual language proficiency and reading performance. Statistical significance was established at $p < 0.05$.

Results:

A total of 80 Urdu–English bilingual students participated in the study. The mean age of participants was 22.8 ± 2.4 years. Females constituted 56.3% of the sample, while males accounted for 43.7%. Most participants reported using both Urdu and

English daily for academic and personal communication.

Table 1. Demographic Characteristics of Participants

SPD Status	Frequency	Percentage
Present	88	35.2%
Absent	162	64.8%
Total	250	100%

Thematic analysis generated four major themes and eleven subthemes describing faculty members' experiences following participation in the MCQ development workshop.

Variable	SPD Present (%)	SPD Absent (%)	p-value
Primigravida	24 (27.3)	76 (46.9)	0.012
Multiparous	64 (72.7)	86 (53.1)	
Normal BMI	26 (29.5)	78 (48.1)	0.008
Overweight/Obese	62 (70.5)	84 (51.9)	
Second Trimester	28 (31.8)	82 (50.6)	0.001
Third Trimester	60 (68.2)	80 (49.4)	

Quality of Life

Table 3: Women with SPD reported significantly lower quality-of-life scores than those without SPD.

Group	Mean SF-12 Score	SD	p-value
SPD Present	48.3	8.2	<0.001
SPD Absent	71.5	7.6	

Functional Mobility

Table 4: Participants with SPD demonstrated poorer mobility performance.

Group	Mean TUG Time (seconds)	SD	p-value
SPD Present	13.7	2.8	<0.001
SPD Absent	9.8	1.9	

Correlation Analysis

PGQ scores exhibited:

- Strong negative correlation with SF-12 scores ($r = -0.69$, $p < 0.001$).
- Moderate positive correlation with TUG times ($r = 0.61$, $p < 0.001$).

From the above results, it can be seen that there was a relationship between the increase in SPD and an increase in poor quality of life and mobility problems.

Discussion:

A total of 80 Urdu–English bilingual students participated in the study. The mean age of

participants was 22.8 ± 2.4 years. Females constituted 56.3% of the sample, while males accounted for 43.7%. Most participants reported using both Urdu and English daily for academic and personal communication.

One of the principal findings of this study was the significant difference in reading time between Urdu and English. Participants processed English sentences more quickly than Urdu sentences. This difference may be attributed to several factors. English serves as the primary language of instruction in higher education in Pakistan, particularly in science, medicine, engineering, and professional disciplines. Consequently, university students spend considerable time reading English textbooks, research articles, and examination materials. Greater exposure to English academic texts may result in increased automaticity in lexical access and syntactic processing, leading to faster reading performance despite Urdu being the participants' first language.

The visual characteristics of the Urdu writing system may also contribute to slower reading speed. Urdu employs the Nastaliq script, which is highly cursive and context dependent, with letter shapes varying according to their position within words. In contrast, the Roman alphabet used in English consists of comparatively simpler and more visually distinct letter forms. The perceptual complexity of Nastaliq script may increase visual processing demands, thereby extending fixation duration and slowing sentence processing. Although the present study did not include eye-tracking measures, the observed behavioral differences are consistent with previous psycholinguistic

findings demonstrating that orthographic complexity influences reading efficiency.

Response latency also differed significantly between language conditions, with participants responding more rapidly following English sentences. Response latency reflects not only reading speed but also the cognitive processes involved in integrating sentence meaning, retrieving relevant information, and selecting the correct response. The shorter response times observed during English sentence processing suggest greater processing fluency, possibly resulting from participants' frequent academic exposure to English. However, the relatively small difference between the two language conditions indicates that bilingual readers rapidly adapt when switching between scripts with opposite reading directions.

An important finding was that comprehension accuracy remained consistently high for both Urdu and English despite differences in processing speed. Participants achieved mean comprehension scores exceeding 90% in both language conditions, indicating that slower reading did not impair understanding. This finding suggests that proficient bilingual readers may compensate for increased perceptual demands by allocating additional cognitive resources to sentence interpretation. Rather than sacrificing comprehension, participants appeared to adopt a more deliberate reading strategy when processing the more visually demanding script.

The positive association between bilingual language proficiency and sentence-processing performance further supports this

interpretation. Higher proficiency in both Urdu and English was associated with faster reading, shorter response latency, and greater comprehension accuracy. These findings are consistent with models of bilingual language processing that propose increased efficiency through repeated experience managing two linguistic systems. Regular switching between Urdu and English may strengthen executive functions such as attentional control, cognitive flexibility, and inhibitory processes, enabling bilingual individuals to adjust efficiently to changes in orthographic direction.

The results also support the concept of cognitive adaptability among bilingual readers. Managing languages with opposing writing directions requires continuous modification of eye movement patterns, attentional orientation, and orthographic processing strategies. Over time, these repeated adjustments may promote greater flexibility in visuospatial attention and language control mechanisms. The high comprehension accuracy observed across both language conditions suggests that bilingual readers successfully develop adaptive strategies that minimize the potential cognitive costs associated with switching between scripts.

The findings have important implications for theories of bilingual language processing. Interactive models of bilingual lexical access propose that both languages remain simultaneously activated during reading and that language selection depends on cognitive control mechanisms rather than complete suppression of the non-target language. The present findings support these models by demonstrating that bilingual readers

efficiently process both scripts despite their contrasting orthographic characteristics. Differences in processing speed likely reflect variations in orthographic familiarity and visual complexity rather than fundamental limitations in bilingual sentence comprehension.

From an educational perspective, the findings highlight the importance of considering script direction in multilingual learning environments. Students in Pakistan routinely alternate between Urdu and English while reading textbooks, completing examinations, and accessing digital resources. Although bilingual students generally comprehend material accurately in both languages, differences in reading efficiency may influence performance under timed examination conditions. Educators and assessment designers should therefore recognize that orthographic characteristics may contribute to variations in task completion time, particularly when students are required to switch frequently between languages.

The findings also have implications for bilingual literacy instruction. Educational programs should encourage balanced development of reading skills in both Urdu and English while providing opportunities for learners to practice switching between writing systems. Such experiences may strengthen cognitive flexibility and improve processing efficiency across languages. Additionally, digital learning resources should consider script-specific visual design to enhance readability and reduce unnecessary cognitive load.

Several strengths enhance the contribution of this study. First, the within-subject design allowed direct comparison of sentence-processing performance across Urdu and English while controlling for individual differences in cognitive ability. Second, multiple behavioral measures, including reading time, response latency, and comprehension accuracy, provided a comprehensive assessment of sentence processing. Third, the study contributes to an underrepresented area of psycholinguistic research by focusing on Urdu–English bilinguals, a population that has received comparatively little empirical attention despite representing millions of bilingual speakers worldwide.

Despite these strengths, certain limitations should be acknowledged. The study relied on convenience sampling from a single university, which may limit the generalizability of the findings to other bilingual populations. Reading performance was assessed using behavioral measures rather than eye-tracking or neurophysiological techniques, preventing direct observation of visual attention and neural processing during reading. Furthermore, bilingual proficiency was based partly on self-report, which may not fully reflect objective language competence. Future studies should incorporate standardized language proficiency assessments together with eye-tracking, electroencephalography (EEG), or functional neuroimaging to provide a more detailed understanding of the mechanisms underlying cross-script sentence processing. Longitudinal studies examining the

development of reading-direction adaptation across different age groups would also contribute valuable evidence.

Overall, the findings demonstrate that reading direction influences the efficiency, but not the accuracy, of sentence interpretation among Urdu–English bilingual readers. The results suggest that bilingual experience promotes flexible cognitive strategies that enable individuals to navigate two contrasting orthographic systems successfully while maintaining high levels of comprehension. These findings contribute to current understanding of bilingual cognition and emphasize the importance of considering orthographic characteristics when investigating language processing in multilingual populations.

Conclusion:

The present study investigated the influence of reading direction on sentence interpretation among Urdu–English bilingual readers. The findings revealed that participants processed English sentences more quickly than Urdu sentences, indicating that orthographic direction and script characteristics influence reading efficiency. However, comprehension accuracy remained consistently high across both languages, suggesting that proficient bilingual readers effectively adapt to contrasting writing systems without compromising understanding. Higher bilingual language proficiency was associated with faster reading, shorter response latency, and improved comprehension, highlighting the role of language experience in facilitating efficient sentence processing.

These findings support the view that bilingual readers possess considerable cognitive

flexibility, enabling them to adjust attentional and linguistic processing strategies according to the demands of different scripts. The study contributes to the growing body of psycholinguistic literature by providing evidence from Urdu–English bilinguals, an understudied bilingual population. From an educational perspective, the results underscore the importance of recognizing the cognitive demands associated with switching between left-to-right and right-to-left writing systems when designing instructional materials and assessments. Future research employing eye-tracking, electrophysiological techniques, and longitudinal designs may further clarify the cognitive and neural mechanisms through which reading direction shapes bilingual language processing.

Authors' Contribution:

AS and KH made contributions to the analysis and interpretation of data and revising the manuscript critically for important intellectual content.

Conflict of Interest:

Authors declare no conflict of interest.

Funding and Ethics:

This research was self-funded by the author.

The study was conducted in accordance with ethical guidelines.

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