Research Article

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The influence of grammatical gender on cognition: the case of German and Farsi

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Abstract: This study investigates whether and how grammatical gender influences cognition by comparing speakers of German, a language with three grammatical genders (masculine, feminine, neutral), and Farsi, a genderless language. Using object description tasks, we examined how grammatical gender affects the assignment of descriptive properties to objects. German monolinguals demonstrated significant effects of grammatical gender on object categorization. This effect was particularly evident in the first adjectives produced, indicating an immediate and automatic link between grammatical gender and conceptual representation. In contrast, Farsi monolinguals showed no such effects, consistent with Farsi's lack of grammatical gender, and their adjective choices were unaffected by gender category, adjective order, sex, or age. Notably, German speakers perceived objects with neutral grammatical gender as genuinely neutral, underscoring the cognitive reality of the neuter category. These findings highlight how the presence or absence of grammatical gender in a language shapes cognitive processing and support linguistic relativity. The study also emphasizes the importance of including neutral gender and of cross-linguistic comparisons in future research to deepen our understanding of language–thought interactions.

Keywords: grammatical gender; cognition; conceptual representation; linguistic relativity

1 Introduction

In the realm of linguistic diversity, some grammatical categories vary significantly across languages (Haspelmath et al. 2005). This variation is observed even across languages within the same language family, such as the Indo-European family, highlighting the nuanced structural evolution of grammar caused by historical and functional adaptations (Comrie 1989). Thus, different languages may vary in case marking (extensive case systems in Russian versus limited or no cases in Romance languages) or in verb conjugation patterns (complex aspectual marking in Slavic languages versus simpler tense systems in Germanic languages) (Comrie 1989). This study focuses on one of these grammatical categories: grammatical gender, present in some languages, yet notably absent in others (Corbett 1991).

Understanding these variations is crucial as they provide insights into how language shapes cognition (Boroditsky 2011), influences social interactions (Gumperz 1982), and reflects cultural values (Duranti 2011). Grammatical gender, in particular, can affect how speakers perceive and categorize the world, with implications for identity, communication, and gender biases (Boroditsky et al. 2003). Examining these variations enhances our understanding of linguistic diversity and its profound influence on thought and society.

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The purpose of the present study is to explore whether grammatical gender influences cognition[1] at the level of conceptualization.[2] Previous studies have demonstrated differences in how speakers of languages with grammatical gender perceive and categorize objects compared to speakers of languages without grammatical gender (Sedlmeier et al. 2016; Sera et al. 2002). This study further investigates these differences in categorization. Specifically, it examines whether grammatical gender leaves traces on how speakers conceptualize objects. Do German and Farsi speakers have distinct associations regarding gender attributes assigned, for example, to the noun 'cloud'? Do German speakers categorize 'cloud' as feminine ('die Wolke'), while Farsi speakers attribute no gender to 'cloud' ('ابر' /ʔaˈbaɻ/)? In contrast, a speaker of French would perceive 'cloud' as masculine ('le nuage'), highlighting the differences among these languages: 'die Wolke' is feminine in German, 'le nuage' is masculine in French, and 'ابر' /ʔaˈbaɻ/ is genderless in Farsi.

To investigate the link between grammatical gender and cognition, this study turns to *the principle of linguistic relativity*, often referred to as *the Sapir-Whorf hypothesis*. This hypothesis posits that the grammatical features inherent in the languages we speak influence our conceptualization and worldview (Lucy 2016; Whorf 1956). Whorf (1956), followed by other scholars, argued that languages impose external impressions through their grammar (Gentner and Goldin 2003; Gumperz and Levinson 1991; Lucy 1992; Whorf 1956). This study explores how the grammatical gender of nouns may contribute to these categorical differences, particularly in the context of German and Farsi.

Grammatical gender, as one of the obligatory properties of nouns in some languages, was researched within the relativity framework as early as the 1990s (Konishi 1993; Sera et al. 1994). Yet, these studies yielded inconsistent outcomes. Some of them found an impact of grammatical gender on conceptualization – particularly in how objects are categorized and perceived – while others found no such influence, suggesting that cognitive effects may vary depending on context or methodology (Flaherty 2001; Imai et al. 2014; Landor 2014; Mickan et al. 2014; Montefinese et al. 2019).

The inconsistency in results is not tied solely to task variations and methodologies. There is a contentious debate within the psycholinguistic and sociolinguistic literature about associating grammatical gender with masculinity and femininity due to the perceived associations with biological gender or sex (Bender et al. 2011; Samuel et al. 2019). Yet, in many languages, the gender distinction does not coincide with a sex distinction. For instance, in grammatically gendered languages such as Dutch and Swedish, a *common gender* includes what other languages classify as *masculine* or *feminine* (Bender et al. 2011). The complexity of grammatical gender is particularly pronounced in German, where three genders must be assigned not only to animate but also to inanimate objects. For example, nouns such as *der Tisch* (the table, masculine), *die Lampe* (the lamp, feminine), and *das Buch* (the book, neuter) illustrate this intricacy. Consequently, much of the existing literature often fails to incorporate these non-binary grammatical gender forms in their experimental tasks (Bender et al. 2016a, 2016b; Imai et al. 2014). Instead, researchers frequently simplify the process by prompting participants to make binary gender judgments (male/female), thus overlooking the nuanced gender system of such languages such as German. To remedy this situation, researchers should revise the tasks employed to investigate the influence of grammatical gender on cognition, ensuring experiments encompass the full range of grammatical categories. Such an approach would facilitate a more comprehensive understanding of how these diverse grammatical forms impact cognition rather than limiting the analysis to binary gender judgments.

To enhance inclusivity in grammatical gender research, this study adopts Whorf's (1956) and Lucy's (2016) argument to investigate the influence of grammatical gender on conceptualization in native German speakers and compares the perspectives of German speakers' responses with those of Farsi speakers. Unlike three-folded gendered German, Farsi, another Indo-European language, is genderless. Thus, this study explores whether native speakers of Farsi and German conceptualize the world differently based on their language. This research

1 The term "cognition" encompasses a range of mental processes involved in acquiring knowledge and understanding through thought, experience, and senses. These processes take place at different levels, including perception, attention, memory, reasoning, and conceptualization, which involves forming and organizing concepts based on experiences (Langacker 1987).

2 This process is influenced by linguistic and cultural factors, shaping how individuals categorize and interpret their experiences (Boroditsky 2001).

trajectory allows for further scrutiny of the linguistic relativity hypothesis. The study seeks to answer the following research questions:

(1) Does the grammatical gender of the nouns influence the assignment of properties to objects and animals by German native speakers?
(2) Do Farsi native speakers differ from German native speakers in assigning properties to objects and animals?

To address these research questions, this paper is structured as follows. Section 2 provides the theoretical framework, beginning with an overview of linguistic relativity and its spectrum (2.1), followed by a discussion of grammatical gender as an obligatory feature in certain languages (2.2). Section 2.3 examines the gender systems of German and Farsi, while Section 2.4 reviews previous research on the influence of grammatical gender on cognition within the linguistic relativity framework. Section 3 outlines the methodology of the present study, detailing the experimental design and analytical approach. Section 4 presents the results, and Section 5 discusses their implications in relation to the research questions, concluding with a synthesis of the study's contributions and future research directions.

2 Theoretical framework

2.1 Linguistic relativity and its spectrum

Linguistic relativity, also known as the Sapir-Whorf hypothesis, is typically discussed in terms of strong and weak versions. The strong version holds that language determines thought and restricts cognitive abilities, while the weak version suggests that language influences thought and perception without fully constraining them (Whorf 1956). Few contemporary scholars endorse the strong determinist position (Athanasopoulos 2009).

At the opposite end of this spectrum lies the universalist perspective, which posits that thought is independent of language (Pinker 1994). Between these two extremes lie various intermediate positions. One such view is the *thinking-for-speaking* hypothesis, which argues that language guides our attention toward perceptual features that are more easily described linguistically, thereby shaping thought as we engage in speaking (Boroditsky 2011; Slobin 1996, 91). Mertins (2018) extended this idea with the *seeing-for-speaking* hypothesis, which emphasizes that visual perception precedes and is influenced by the grammatical encoding required by a given language.

The extent to which language shapes perception and cognition remains controversial. Many scholars agree that our perceptions and conceptualizations are influenced or shaped by language (Athanasopoulos 2006; Dolscheid et al. 2013; Lucy 2016). According to Lucy (2016, 498), it is now widely acknowledged that language-specific patterns can impact cognition, and the burden of proof lies with those who deny these effects. However, as Malt and Wolff (2010) argue, the relationship between language and cognition is complex: some cognitive processes – such as categorization, memory, attention, conceptualization, and pragmatics – may be more affected by linguistic structures than others. This suggests that language influences thought to varying degrees depending on the specific cognitive domain or task involved.

Numerous studies have demonstrated language effects across cognitive domains, including color, pitch, number, motion, and time (Athanasopoulos 2006; Athanasopoulos and Bylund 2013; Boroditsky 2001; Dolscheid et al. 2013; Roberson et al. 2008; Stutterheim and Nüse 2003). For example, Athanasopoulos (2009) showed that bilingual Greek-English speakers shift their cognitive color representations based on language dominance and cultural context. Similarly, Dolscheid et al. (2013) found that Dutch and Farsi speakers, who use different metaphors for pitch (high/low versus thin/thick), represented pitch differently in non-verbal tasks.

Athanasopoulos (2006) found that Japanese-English bilinguals showed different numerical judgments depending on their L2 proficiency. While Japanese monolinguals, whose language lacks plural marking, focused on non-countable objects, advanced L2 speakers aligned more closely with English speakers, suggesting grammar can shape – and be reshaped – by language learning.

Stutterheim and Nüse (2003) demonstrated that speakers of English, German, and Algerian Arabic segment motion events differently due to language-specific patterns of perspective-taking. Boroditsky (2001) found that English and Mandarin speakers conceptualized time using horizontal and vertical spatial metaphors, respectively – differences that persisted even in non-verbal reasoning tasks.

Research on grammatical gender falls within this broader tradition of investigating how linguistic structures affect cognition (Almutrafi 2015; Athanasopoulos and Boutonnet 2016; Bassetti 2007; Beller et al. 2015; Bender et al. 2016a; Haertlé 2017). These studies explore how grammatical gender influences cognitive processes such as object perception, categorization, and gender associations.

For example, Almutrafi (2015) found that Arabic speakers, whose language includes grammatical gender, showed gender-based voice attribution in object judgments – effects absent in English speakers. Beller et al. (2015) found that voice assignment patterns in gendered languages were shaped both by grammatical gender and cultural context. Similarly, Bassetti (2007) observed that Italian-German bilinguals showed weaker gendered conceptualization when exposed to conflicting grammatical gender cues across their two languages.

Haertlé (2017) examined how grammatical gender shaped perceptions of natural versus artificial objects in Polish and French speakers. The study demonstrated that grammatical gender cues can lead to gendered assessments of objects. In contrast, Bender et al. (2016a) found that gender congruency effects were often item-specific rather than driven by grammatical gender.

These findings suggest that grammatical gender contributes to how people conceptualize and categorize objects, but that its effects are nuanced, shaped by context, culture, and task design.

2.2 Grammatical gender: an obligatory feature in some languages

Grammatical gender systematically classifies nouns into categories, typically based on attributes such as sex (e.g., masculine, feminine) or other inherent properties. According to Hockett (1960), grammatical gender categories are revealed through agreement patterns of related words, including adjectives, determiners, and verbs. This means that the grammatical gender of a noun governs the form of words that syntactically agree with it. For example, in German, adjectives and determiners must align with the noun's gender, as in *eine kleine Flasche* ('a small bottle'), where *eine* (a) and *kleine* (small) agree with the feminine noun *Flasche* (bottle). In languages with grammatical gender, such agreement is an obligatory structural feature distinguishing noun classes and enabling syntactic consistency.

While grammatical gender sometimes aligns with real-world sex distinctions, this alignment is often partial or absent (Corbett 1991). For instance, in German, *Mädchen* ('girl') has neuter gender despite referring to a feminine entity. Similarly, in Polish, the diminutive *dziewczę* ('girl') carries neuter gender, and some nouns for females may adopt masculine gender and vice versa (Maciuszek et al. 2019).

Languages such as Czech demonstrate the pervasive nature of grammatical gender, with adjectives always carrying gender-specific endings and lacking a base form. For example, *velký* ('big') appears as masculine, *velká* feminine, and *velké* neuter, requiring adjective endings to match the noun's gender (Tahal 2010). This highlights the obligatory nature of grammatical gender in such languages.

Exploring grammatical gender as an obligatory feature helps illuminate how language might influence our worldview. As Lucy (1992) argues, distinguishing obligatory categories from optional ones is essential to understanding how structural imperatives differ from usage preferences (Lucy 2016, 489).

Grammatical gender varies across languages in the number of categories and marking mechanisms. One group features a three-gender system, realized through pre-nominal articles (e.g., German der, die, das) or post-nominal suffixes (e.g., Polish). In Czech, three genders are also marked by post-verbal suffixes (-y, -i) that indicate gender and plurality in verb forms, crucial for grammatical agreement (Fatemi 2023; Tahal 2010).

The second group employs a binary gender system in which grammatical gender predominantly distinguishes between feminine and masculine forms. Languages such as Spanish, French, and Portuguese mark gender distinctions through pre-nominal articles and post-nominal suffixes (Corbett 1991).

The third group includes natural gender languages such as English, where gender is primarily indicated through pronouns (he, she, it), aligning mostly with biological sex (Corbett 1991; Prewitt-Freilino et al. 2012). While some classify English as genderless due to the lack of grammatical gender marking on inanimate nouns (Forbes et al. 2008; Kousta et al. 2008), English enforces gender agreement in pronoun use (e.g., she for girl), reflecting a gender system (Corbett 1991).

In conclusion, grammatical gender is an obligatory feature across these three types of languages – three-gender, two-gender, and natural-gender systems – expressed through various linguistic mechanisms such as articles, suffixes, or pronouns. These markings are represented in morphosyntax, affecting sentence structure, verb tense, and inflection of related words (Corbett 1991). For speakers aiming for grammatical accuracy, awareness of their language's grammatical gender system is essential.

Not all languages conform to these patterns; for example, Farsi lacks grammatical gender distinctions entirely (Esmaili 2023). Such variation underscores the importance of exploring how structural differences in grammatical gender systems might influence cognition and conceptualization, setting the stage for the following examination of grammatical gender in German and noun phrase structure in Farsi.

2.3 Gender system in German and Farsi

This study focuses on a cross-linguistic comparison between German and Farsi in terms of grammatical gender. German features a grammatical gender system with three categories – feminine, masculine, and neuter – governed by both semantic and formal rules (Dudenredaktion 2005; Duke 2005). In contrast, Farsi lacks grammatical gender distinctions entirely, placing the two languages at opposite ends of the grammatical gender spectrum (Fatemi 2023). This divergence makes them ideal for critically examining the linguistic relativity hypothesis, which posits that grammatical structures influence cognition (Lucy 2016, 487–490).

In German, grammatical gender is pervasive and affects nouns, articles, and adjectives across the four grammatical cases – nominative, accusative, dative, and genitive – resulting in dynamic inflectional patterns. Gender assignment in German relies on semantic categories (e.g., *der Mann* 'the man' is masculine; *die Frau* 'the woman' is feminine) and formal markers, such as suffixes (e.g., nouns ending in -er are usually masculine, while -e indicates feminine). Tables 1 and 2 summarize these semantic and morphological criteria (Dudenredaktion 2005).

Nevertheless, a significant number of exceptions persist in nouns whose gender cannot be deduced through the aforementioned principles. For instance, diminutive nouns in German are obligatorily assigned the neuter gender, regardless of the natural biological gender of the referent. Examples include "*das Mädchen*" (the girl) and "*das Büblein*" (the little boy). These cases highlight the precedence of grammatical rules over natural gender in such instances. Similarly, nouns such as "*der Käse*" (the cheese) and "*die Jeans*" (the jeans) deviate from formal assignment criteria. Overall, these exceptions underscore the nuanced and occasionally non-intuitive nature of the German gender system.

Considering the frequency with which grammatical gender is realized in basic syntactic structures in German, it becomes evident that this feature is inherently present in all linguistic expressions, continuously

Table 1: Grammatical gender classes in German: semantic criteria overview.

Grammatical gender class/gender class	Semantic criteria
Masculine	Seasons, months, days of the week, star constellations, winds, forms of precipitation, types of soil and rock, currencies, proper names for male persons, mountains, and cars
Feminine	Individual flowers and trees, some abstract concepts, nominalized numbers, fonts, names denoting female persons, ships and airplanes (especially those named after places), motorcycles
Neutral	Most types of metal, chemical elements and medications, diminutives (including proper names), nominalized parts of speech and letters (das A), collectives and pejorative terms beginning with Ge-, place names in general, most names of countries, hotels, cafes, and cinemas

Table 2: Grammatical gender classes in German: formal criteria overview.

Grammatical gender class/gender class	Formal criteria
Masculine	-ich, -ig, -ling, -s, -and, -ant, -är, -ast, -eur / -ör, -ient, -ier, -iker, -ikus, -ismus, -ist, -or
Feminine	-e, -ei, -itl, -heit, -keit, -schüft, -ung, -a, -ade, -age, -aille, -aise / -äse, -ance, -äne, -anˆ -ation, -elk, ette, -euse, -ie, -{i) entˆ -(i)ere, -ik, -tile, -ine, ion / -ation, -isse, -(i)tät, -itis, -ive, -ose, -sis / -se, ur, -ürr
Neutral	-chen, -lein, -le, -icht, -tel, -tum, -eau / -o, -ett, in, -ing, - (, i) um, -ma, -ment

influencing syntactic structures at every level of language use. This feature exhibits a dynamic nature across the four grammatical cases – nominative, accusative, dative, and genitive. In each case, the articles and potentially accompanying adjectives are modified according to the specific grammatical gender of the noun, highlighting the inherent variability of grammatical gender across different linguistic contexts. Furthermore, the definite and indefinite forms of the noun introduce an additional layer of complexity. The articles, both definite and indefinite, undergo declination in different forms across these four cases in German, which further illustrates the syntactic and morphological role of grammatical gender as an integral feature of the German language (Dudenredaktion 2005). Table 3 illustrates inflection patterns for feminine nouns, showing how articles and adjectives change across cases. These patterns differ for masculine and neuter nouns, emphasizing grammatical gender's impact on morphosyntactic structure.

As depicted above, grammatical gender is a fundamental and obligatory feature of German. The language exhibits a robust obligatory gender system, where morphological cues embedded in nouns, adjectives, and articles enforce consistent agreement across syntactic contexts. This pervasive feature significantly shapes the structure of the language.

Farsi,[3] on the other hand, is a gender-neutral language with a simpler nominal system (Sagot and Walther 2010) and no grammatical gender. While it lacks morphological case marking (Lazard and Paper 1959),

Table 3: Declination of feminine nouns with definite and indefinite articles across German cases.

Cases	Adjective + definite/indefinite noun (feminine)		
Nominative	*Die*	*schön-e*	*Tochter*
	The (F.NOM. ART.)	nice-F.SG	daughter
	eine	*schön-e*	*Tochter*
	a (F. INDF. ART.)	nice-F.SG	daughter
Accusative	*Die*	*schön-e*	*Tochter*
	The (F.ACC. ART.)	nice-F.SG	daughter
	eine	*schön-e*	*Tochter*
	a (F. INDF.ACC ART.)	nice-F.SG	daughter
Dative	*Der*	*schön-en*	*Tochter*
	The (F.DAT. ART)	nice-F.DAT.SG	daughter
	einer	*schön-en*	*Tochter*
	a (F. INDF.DAT. ART.)	nice-F.SG	daughter
Genitive	*Der*	*schön-en*	*Tochter*
	The (F.GEN. ART)	nice-F.GEN.SG	daughter
	einer	*schön-en*	*Tochter*
	a (F. INDF.GEN. ART.)	nice-F.GEN.SG	daughter

3 In this article, the term Farsi is used to refer collectively to Persian, Parsi, and Dari for the sake of clarity and accessibility. Farsi is an inflectional language with a subject-object-verb (SOV) word order and is written from right to left. It belongs to the Western Iranian branch of the Indo-European language family and is predominantly spoken in Iran.

Table 4: Case system in Farsi.

Cases	Adjective + definite/indefinite noun (feminine)			
Nominative	آمد/amæd come-PST-3rd s The beautiful girl came.	زیبا/ziba Beautiful/ATTR	دخترِ/Dokhtær-e girl	
Accusative	بوسید/bus-id kiss-PST-3rd s The father kissed the daughter.	را/ra postposition “râ” ACC-marker	دختر/dokhtær girl/daughter. ACC	پدر/pedær father
Dative/ Completive	کمك کرد/komak-kærd help-did-3rd The father helped the daughter.	دختر/dokhtær girl/daughter/IOBJ	به/be preposition “be” to	پدر/pedær father
Predicative	است/æst To be-3rd SG The weather is cold.	سرد/særd ADJ.PRED cold	هوا/hæva weather	
Genitive	است/æst to be-3rd SG Maryam’s mother is beautiful.	زیبا/ziba beautiful- adj	مریم/Maryam Maryam	/e EZ/GEN-marker	مادر/madær mother
Attributive	آمد/amæd come-PST-3rd s The devoted mother came.	فداکار/fædakar devoted/adj	/e EZ/GEN-marker	مادر/madær mother
Vocative	خدا/Xoda God Oh god!		اي/ey Oh/EXCLM	
Adverbial	است/æst to be-3rd SG The bird is on the tree.	درخت/derækht tree/LOC	روي/ruye on/PREP	پرنده/pærænde bird
Object completive	نامم/mi-nam-æm PRS. PREFIX.to name. 1ST SG I name him Armin.	آرمین/Armin OBJ.CMPL	را/ræ postposition “râ”. ACC- marker	او/u PRO.3rd SG	من/mæn I
Appositive case	بود/bud to be-PS.3rd SG Yesterday, Armin, the carpenter, was here	اینجا/indʒa here.ADV	نجار/Nædʒar carpenter.APPOS	آرمین/Armin	دیروز/Diruz yesterday

researchers note ten semantic and syntactic case roles in Farsi (Ahamadi-Givi 2004; Khayyampour 1998). These include nominative, accusative, dative, genitive, attributive, predicative, adverbial, object-completive, vocative, and appositive, as shown in Table 4.

In Farsi, case relationships are expressed through prepositions, postpositions, and syntax rather than inflected endings. The nominative case identifies the subject of a sentence, typically positioned at the beginning. The accusative case is marked by the postposition [ra], essential for direct objects of transitive verbs such as *busidæn* (to kiss). The dative case employs prepositions such as [bɛ] to indicate indirect objects, while the predicative case is formed with the copula verb *budan* (to be). Genitive and attributive relationships are expressed by using the Ezafe marker [-e], which links nouns or adjectives (e.g., *ketab-e man* “my book”). Notably, this marker is pronounced but remains unwritten in standard Farsi. Other roles, such as vocative, adverbial, and object-completive, rely on word order and context rather than explicit markers. Similarly, the appositive case clarifies a noun and is inferred from sentence semantics. These features demonstrate Farsi’s reliance on syntactic and auxiliary elements to establish grammatical relationships and its avoiding fixed morphological rules.

By contrasting grammatically gendered German with genderless Farsi, we explore how grammatical gender may influence cognition. If German speakers show a significant influence of grammatical gender on their conceptualization of nouns, while Farsi speakers exhibit divergent patterns, we claim that these results lend

support to the linguistic relativity hypothesis. Thus, this analysis highlights the cognitive implications of grammatical gender and the broader relationship between language and thought.

2.4 Navigating gendered constructs: insights from linguistic relativity studies

2.4.1 Previous research

Research into the influence of grammatical gender on cognition spans over a century, with studies dating back to 1915, predating the Sapir-Whorf hypothesis (Konishi 1993). Konishi (1993) discusses how grammatical gender may guide speakers to anthropomorphize words based on the grammatical gender assigned to objects in their languages. For instance, a seminal 1915 Russian study found that participants consistently personified Monday, Tuesday, and Thursday as masculine, aligning with their grammatical gender, while Wednesday, Friday, and Saturday were personified as feminine (Konishi 1993).

Following the Sapir-Whorf hypothesis, numerous studies have investigated how grammatical gender influences cognitive processes. Sera et al. (1994) used classification tasks to examine whether Spanish speakers assign gendered attributes to objects based on grammatical gender. They found Spanish speakers tended to attribute masculine or feminine qualities consistent with grammatical gender in Spanish, whereas English speakers, whose language lacks grammatical gender, associated masculine traits with artificial objects and feminine traits with natural ones. Subsequent research extended these findings to languages such as Arabic, French, and Norwegian using voice-assignment tasks (Almutrafi 2015; Athanasopoulos and Boutonnet 2016; Beller et al. 2015). Although these studies support the hypothesis that grammatical gender shapes conceptualization, the use of explicit gender-judgment tasks raises questions about whether the effects reflect unconscious linguistic influences or conscious reasoning.

Boroditsky et al. (2003) conducted a widely cited study in which German and Spanish speakers described objects using adjectives. They found that participants tended to choose adjectives aligned with the grammatical gender of the object in their native language – for example, describing the German masculine word *Schlüssel* ('key') as 'hard' or 'heavy,' and the Spanish feminine word *llave* ('key') as 'lovely' or 'intricate.' However, this study excluded nouns that are grammatically neuter in German and did not include statistical analyses. In a follow-up study by Phillips and Boroditsky (2003), participants rated the similarity between pairs consisting of a human figure (male or female) and an inanimate object or animal with masculine or feminine grammatical gender. Although conducted in English, similarity judgments were influenced by grammatical gender congruency in German and Spanish, suggesting that native grammatical gender systems shape conceptual associations beyond native language use.

Some scholars argue that grammatical gender effects are evident only in languages with two grammatical genders, such as Arabic, Italian, French, and Spanish (Sera et al. 2002; Vigliocco et al. 2005). They used categorization tasks and found no effects in languages with more than two grammatical genders, such as German. However, contrary evidence exists from studies on Polish, a three-gender language, which demonstrated that grammatical gender effects can occur in three-gendered languages (Haertlé 2017; Maciuszek et al. 2019). This suggests that restricting the influence of grammatical gender on cognition to two-gender languages is not logically sound, highlighting the need for further research across diverse grammatical gender systems.

More recent replication attempts (Elpers et al. 2022) with improved methodologies and larger samples have yielded mixed results, finding no effect of grammatical gender on similarity judgments between German and Spanish speakers. These mixed findings highlight the complexity of comparing languages with different gender systems (three genders in German versus two in Spanish).

Electrophysiological studies using electroencephalogram (EEG)[4] provide evidence for implicit, unconscious activation of grammatical gender during language processing (Boutonnet et al. 2012; Sato et al. 2020).

4 EEG, widely utilized in psycholinguistics, measures electrical brain activity and serves as an effective tool to capture automatic and unconscious neural responses during language processing.

Event-related potential components (ERP) such as the N400[5] and Left-Anterior Negativity (LAN)[6] indicate morphosyntactic processing even when gender is not explicitly judged, supporting the view that grammatical gender influences cognition beyond conscious awareness.

Behavioral paradigms such as the Extrinsic Affective Simon Test (EAST),[7] which measures implicit associations between stimuli and affective responses, have been used to assess gender congruency effects (Bender et al. 2016a, 2018). These studies found stronger grammatical gender effects for animate objects whose biological sex matches grammatical gender, while effects for inanimate or grammatically neuter nouns were weaker or item-specific. Importantly, these tasks probe implicit processing, unlike explicit voice assignment tasks that involve conscious judgments.

Cross-linguistic comparisons with genderless languages, such as Tamil (Sedlmeier et al. 2016), emphasize the unique role of grammatical gender in shaping cognition. These studies found significant gender effects in German but not in Tamil, suggesting that grammatical gender influences cognition in a language-specific rather than universal manner.

Despite extensive research, significant gaps remain. In particular, the neutral grammatical gender has been underrepresented in previous studies, with most research focusing on masculine and feminine categories, overlooking the complexity of languages such as German with three genders. Additionally, the variety of methods – ranging from explicit to implicit tasks – and the inconsistent findings call for more integrative approaches. A summary of the key studies reviewed in this section is presented in Table 5, providing an overview of the methodologies, language systems, gender categories, and principal findings.

Table 5: Summary of key studies on grammatical gender and cognition.

Study	Language(s)	Methodology/task	Gender focus	Main findings
Konishi (1993)	Russian	Anthropomorphizing days of week	Masculine, feminine	Grammatical gender influences personification of days
Sera et al. (1994)	Spanish, English	Classification, voice assignment	Masculine, feminine	Spanish speakers assigned traits consistent with grammatical gender; English speakers associated masculinity with artificial and femininity with natural objects.
Boroditsky et al. (2003)	German, Spanish	Adjective description, similarity ratings	Masculine, feminine	Gender affects object description and similarity judgments
Phillips and Boroditsky (2003)	German, Spanish	Similarity judgement	Masculine, feminine	Gender affects similarity ratings
Elpers et al. (2022)	German, Spanish, English	Similarity judgments	Masculine, feminine	No significant gender effects on similarity ratings
Boutonnet et al. (2012)	Spanish-English	EEG semantic categorization	Masculine, feminine	Implicit activation of grammatical gender in bilinguals
Sato and Athanasopoulos (2018)	French-English	ERP gender-related judgments	Masculine, feminine	Grammatical gender modulates early neural processing
Bender et al. (2016a, 2018)	German	EAST, voice assignment	Masculine, feminine, neuter	Gender congruency effects vary by animacy and gender type
Sedlmeier et al. (2016)	German, Tamil	Potency scales, adjectivet production & similarity judgement	Masculine, feminine, neuter	Effects found in German but not in genderless Tamil

5 The N400 wave is a negative-going potential peaking around 400 ms post-stimulus, reflecting semantic integration processes (Kutas and Hillyard 1984).

6 The Left-Anterior Negativity is an ERP marker of morphosyntactic processing.

7 Reaction time–based psychological paradigm used to measure implicit associations between concepts – such as grammatical gender and emotional valence – without requiring participants to explicitly judge the relevant features.

This review shows that grammatical gender can influence how speakers assign properties to objects, especially in languages such as German and Spanish. However, findings vary, particularly when comparing languages with different gender systems. A notable gap remains: the limited attention to the neutral grammatical gender and the need for methodologies that balance implicit and explicit measures. The present study addresses these gaps by including neuter nouns in German and contrasting responses with Farsi, a genderless language, for a comprehensive cross-linguistic examination.

3 Methodology

In this paper, we aim at filling some of the research gaps that we detected in the current state of the art. First, the study explores whether the grammatical gender of nouns in German influences their conceptual meaning and the mental representation of objects among L1 German monolingual speakers. Second, the study examines whether Farsi native speakers differ from German native speakers in assigning properties to objects and animals. To answer these questions, a two-phased study was conducted. During the first phase, German and Farsi native speakers completed a property judgment task in which they were asked to describe a set of nouns using the first three adjectives that came to mind. The adjectives generated from these responses were then used in the second phase, where a different group of native German and Farsi speakers rated the adjectives on a Likert scale. The resulting data were analyzed using a Linear Mixed Model, with the mean of the adjective ratings serving as the dependent variable. Post-hoc tests were conducted to further assess the significance of the model's findings.

3.1 Participants

The study involved two phases with two separate groups of participants. In the first phase, 74 German monolinguals[8] and 65 Farsi monolinguals participated. The German monolinguals were recruited from the Dortmund area in Germany (45 females, age: M = 27, SD = 8.3, range: 18–60), while the Farsi monolinguals were recruited from Mashhad, Iran (35 females, age: M = 34.6, SD = 8.2, range: 20–59). In this phase, the participants were asked to describe objects as part of the experimental task.

In the second phase, 106 German monolinguals and 60 Farsi monolinguals were recruited from Dortmund and Mashhad, respectively. The German group consisted of 84 females and 21 males (one participant did not disclose their gender; age: M = 23.7, SD = 3.7, range: 18–49). The Farsi group included 37 females and 23 males (age: M = 35.9, SD = 8.9, range: 16–55). The participants rated the adjectives on a 7-point Likert scale.

In both phases, the participants exhibited comparable age ranges, with standard deviations indicating similar variability in age. Gender distributions were skewed toward females across both groups but remained consistent between phases and regions.

To assess socioeconomic status (SES), educational attainment was used as a proxy. In the first phase, the majority of German participants had completed the Abitur[9] (45.95 %) or held a bachelor's degree (41.89 %), whereas most Farsi participants held a bachelor's degree (65 %). In the second phase, 75.24 % of German participants had completed the Abitur, and 23.81 % had earned bachelor's degrees. Farsi participants in this phase showed a similar pattern to those in the first, with 65 % holding bachelor's degrees. While the overall educational levels were relatively high across both groups, it should be noted that in the second phase, a higher proportion of Farsi participants held bachelor's degrees compared to the German group (65 % vs. 23.81 %). Most German participants were university students who received one ECTS credit as an incentive. The remaining German

8 Speakers were considered monolingual if they had exclusively communicated in either German or Farsi during their preschool years. Additionally, participants were required not to have lived outside Germany or Iran for more than six months up to the age of 22, which was regarded as the typical age for completing a bachelor's degree. This approach ensured that the linguistic competencies of both groups were predominantly influenced by their first language and their extended residence in the country where their first language is spoken.

9 The German Abitur is equivalent to a high school diploma or A-levels in English-speaking countries.

Table 6: Participants' demographic information.

Phase	Group	Total N	Female N	Male N	Age range	Age mean (SD)
Phase 1	German L1	74	45	29	18–60	27 (8.3)
	Farsi L1	65	35	30	20–59	34.6 (8.2)
Phase 2	German L1	106	84	21	18–49	23.7 (3.7)
	Farsi L1	60	37	23	16–55	35.9 (8.9)

participants volunteered without financial compensation. All Farsi participants volunteered and did not receive any financial compensation. Table 6 provides a summary of participant characteristics.

3.2 Material/stimuli selection

The study utilized 30 stimuli, 30 control items, and 45 fillers. The stimuli and five control items were selected from the German version of the Peabody Picture Vocabulary Test (PPVT). These items consisted of everyday vocabulary, represented through pictures of both animate and inanimate objects. A balanced number of feminine, masculine, and neutral stimuli and control items was included, with each category containing ten words.

Out of the 228 PPVT words, 94 refer to objects. Among these, 36 are feminine, 38 are masculine, and 20 are neuter in grammatical gender. The frequencies of these 94 words were obtained using the COSMAS II query interface, accessing the W-Archive of the written language (W-public) – a publicly available subset of the German Reference Corpus (DeReKo) that includes written texts from a variety of genres and includes recent acquisitions. To categorize word frequencies, we used a frequency class table (see Appendix C) following the method outlined on the Ruhr University Bochum's corpus linguistics page (homepage.ruhr-uni-bochum.de/Stephen.Berman/Korpuslinguistik, R Core Team 2023). This method involves transforming raw frequency values into discrete frequency classes using a logarithmic scale, which allows for meaningful comparisons between words across a large frequency range. While DeReKo includes raw frequency data, this classification provides a more interpretable metric for psycholinguistic analysis. The purpose of applying this frequency classification was to ensure that the selected feminine, masculine, and neuter nouns fell within comparable frequency bands, minimizing the potential confounding effect of frequency on participants' responses. From the original pool, we selected the ten nouns from each grammatical gender category with the highest frequency class (i.e., the most frequent items according to the classification system). All remaining analyses, including statistical modeling and visualizations, were conducted using R (R Core Team, 2023).

The control items were lexical items denoting human referents whose grammatical and biological genders aligned with feminine and masculine cases, such as "Mutter" (mother), "Braut" (bride), "Vater" (father), and "Koch" (cook). For neutral grammatical gender, words associated with a specific sex in real life but assigned neutral grammatical gender in German were chosen, such as "Mädchen" (girl), "Herrchen" (master), and "Fräulein" (miss). Additionally, this category included words whose overarching terms have neutral grammatical gender in German but whose real-world references possess a specific biological sex, such as "Geschlecht" (gender), "Opfer" (victim), or "Baby" (baby).

In this study, the linguistic terms of objects and their corresponding images were incorporated. Most stimulus images were adapted from the PPVT, except for the image corresponding to the word "Huhn" (hen), which was sourced from Pixabay's free image collection. Among the five control items – "Archäologin" (female archaeologist), "Athlet" (male athlete), "Zimmermann" (male carpenter), "Ritter" (male knight), and "Fußgängerin" (female pedestrian) – both the terms and their images were adopted from the PPVT. The remaining images were either sourced from Pixabay's free image collection or hand-drawn by a colleague.

The 45 fillers consisted of clock images, with participants tasked with telling the time. These clocks were adapted from an ongoing study conducted by a PhD colleague. The number of fillers was chosen to prevent participants from deducing the study's main objectives while avoiding an overwhelming number of irrelevant

tasks. All images were presented in black and white to avoid triggering gender-specific color associations (e.g., pink as feminine or blue as masculine) that could bias participants' judgments. A comprehensive list of all stimuli images and their corresponding linguistic terms is provided in Tables A1, A2 and A3 (Appendix B).

3.3 Survey procedure

The primary aim of this study was to investigate the influence of grammatical gender on cognition using an online questionnaire administered via LimeSurvey. While all German-speaking participants completed the survey online, a subset of Farsi-speaking participants was unable to do so due to internet shutdowns in Iran. As a result, these participants completed the survey in a pen-and-paper format.

The survey was designed to take no longer than 20 min and included randomized stimuli, control items, and fillers. At the end of the survey, participants completed a linguistic competence questionnaire to gather information on their language acquisition history and to confirm their monolingual status. Demographic information, such as age, sex, and education level, was also collected. The survey was translated into Farsi for Farsi-speaking participants, including all items and the demographic questionnaire.

This study was reviewed and approved by the Joint Ethics Committee of Faculties 9, 11–17 at TU Dortmund University (Approval Number: GEKTUDO_2024-76). The research adhered to ethical guidelines for scientific investigations and was deemed ethically unobjectionable.

At the beginning of the survey, all participants received instructions in both German and Farsi, briefly outlining the tasks. In the first phase, participants were asked to describe images and provide spontaneous responses. A second group of participants then rated the adjectives generated in the first phase. Detailed instructions for both phases, including the image design and their translations, can be found in Appendix A.

4 Results

The initial phase of the study yielded 6,660 adjectives from German monolinguals and 5,850 adjectives from Farsi monolinguals. These adjectives were carefully reviewed based on specific inclusion criteria. First, any spelling errors were corrected. Second, German adjectives derived from Participle 1 were excluded, as these are formed by adding "-d" to the infinitive verb, thus focusing on adjectives independent of verb origins. Additionally, adjectives based on verbs or nouns, rather than pure adjectives, were excluded to ensure consistency. Only adjectives mentioned by participants at least four times were retained to ensure sufficient frequency representation. As a result, 326 German adjectives and 157 Farsi adjectives were included in the final analysis. These adjectives were then presented to a separate group of participants (106 native German speakers and 60 native Farsi speakers) who were unaware of the origin of the adjectives and asked to rate them on a 7-point Likert scale from 1 = very feminine to 7 = very masculine. The primary objective of this second phase was to obtain a quantitative representation of the perceived gender connotation for each adjective. The mean score of each adjective across all raters was then calculated and used as a continuous variable in the subsequent statistical modeling as the response variable. This fine-grained approach was inspired by the methodology of Sedlmeier et al. (2016), though our study employed a significantly larger sample of raters (n = 166 versus n = 6), thus enhancing the reliability and generalizability of the findings.

The analysis of the 326 German adjectives revealed that some were used to describe objects across all three grammatical gender categories, while others were predominantly associated with a specific gender. To facilitate the rating task in the second phase of the study, the 326 adjectives were distributed into six groups, each containing a manageable number of adjectives for evaluation. A total of 194 adjectives were used across all grammatical gender categories (feminine, masculine, and neutral), while the remaining adjectives were specifically linked to a single gender. Each group contained a balanced selection of these adjectives, with a maximum of 60 adjectives per group, ensuring that participants could complete the task without excessive cognitive load. The grouping method aimed to evenly distribute adjectives used across all genders while maintaining the gender-

specific distinctions. A detailed breakdown of the adjective distribution across groups in the second phase of the study is provided in Table 7.

Among the 157 Farsi adjectives, only زیبا (/ʒiˈbɑ/; 'beautiful, nice') was used consistently across all objects. Consequently, this adjective was included in all four groups of Farsi adjectives. Group A and Group B each contained 39 adjectives, Group C included 40 adjectives, and Group D comprised 39 adjectives. These adjectives were subsequently evaluated by the second cohort of participants in Farsi. Table 8 provides detailed breakdown of the adjective distribution across groups.

After the adjective ratings were completed, we calculated the average score for each adjective. Our Likert scale ranged from 1 to 7, indicating the possible minimum and maximum average scores. Strategically equidistant boundaries were introduced to define logical limits for further evaluation. Ratings of [1,3] were labeled as feminine, (3,5] as neutral, and (5,7] as masculine.[10]

The 194 adjectives produced by participants to describe objects of all grammatical genders in German were specifically examined, as these adjectives were suspected to reveal particular tendencies in participant responses. It was found that 81.93 % of these adjectives were categorized as neutral, i.e., with an average score between 3 and 5. In contrast, 10.82 % were assigned as feminine [1,3] and 8.25 % as masculine (5,7].

In the analysis, these average scores of each adjective were employed alongside the key variables of the participants from the first study, such as age, gender, and education level. These variables were integrated into our statistical analysis to account for potential influences on adjective ratings. To provide a comprehensive overview, Figure 1 presents the descriptive analysis of the data for both German and Farsi, utilizing the average scores for each adjective incorporated into our data set.

Figure 1 displays the average scores separated for German and Farsi, categorized according to the grammatical gender system in German. The groupings to feminine, masculine, and neutral for Farsi were adapted from German grammar due to Farsi's genderless system. We observe a downward trend in the median in both German

Table 7: Distribution of adjectives across gender categories and groups in the second phase of the study for German speakers.

Group	Total adjectives	Adjectives used across all gender	Gender-specific adjectives
A	60	29	31
B	59	29	30
C	59	30	29
D	59	30	29
E	45	39	8
F	44	37	8
Total	326	194	

Table 8: Distribution of adjectives across object categories and groups in the second phase of the study for the Farsi speakers.

Group	Total adjectives	Adjectives used across all objects	Object-specific adjectives
A	39	1 (زیبا/ʒiˈbɑ/ - "beautiful, nice")	38
B	39	1 (زیبا/ʒiˈbɑ/ - "beautiful, nice")	38
C	40	1 (زیبا/ʒiˈbɑ/ - "beautiful, nice")	39
D	39	1 (زیبا/ʒiˈbɑ/ - "beautiful, nice")	38
Total	157	1	

10 In this context, the notations [1,3] represent an interval that includes both endpoints, 1 and 3. Conversely (3,5] denotes an interval that begins just after 3 (excluding 3) and includes 5. Similarly, (5,7] indicates an interval starting just after 5 (excluding 5) and including 7.

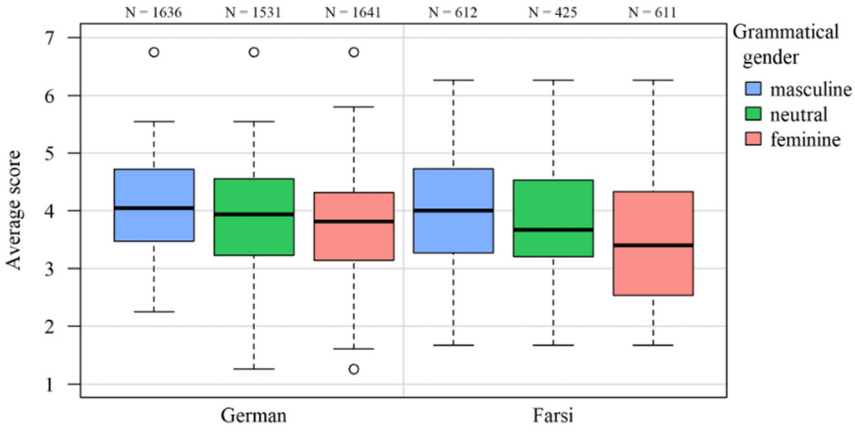

Figure 1: Boxplots of the mean scores separated according to the grammatical gender of the objects for German and Farsi.

and Farsi, progressing from masculine (German median = 4.05, Farsi median = 4.00) to neutral (German median = 3.94, Farsi median = 3.67) and ending with feminine (German median = 3.81, Farsi median = 3.40). What is particularly evident here is the variability in the results. The range of the average score for Farsi speakers is identical across all three groups: feminine, masculine, and neutral. In contrast, the German data indicates less variability for the masculine grammatical gender. However, for feminine and neutral genders in German, the variability is nearly identical. Lexeme-specific variability in both the German and Farsi datasets is further examined in Figures 2, 2.4 and 2.5 (Appendix D), which presents boxplots of the mean adjective scores, grouped by participant gender, the grammatical gender of the stimulus nouns, and the order of the adjectives (1–3), as provided by the participants. Although this visualization enables a more fine-grained examination of how individual lexical items vary across conditions, it does not pertain directly to the core hypothesis of this study. To determine whether the observed differences in average scores are statistically significant, we applied a linear mixed-effects model, following the framework outlined by Fahrmeir et al. (2013).

The following paragraph addresses our research question concerning the potential influence of grammatical gender on German speakers, as determined by the grammatical gender inherent in the stimulus nouns. An extensive analysis was conducted using a linear mixed model (Fahrmeir et al. 2013). The dependent variable was the mean rating of the adjectives on a Likert scale, representing the perceived gender connotation. For each participant and each noun, up to three adjective ratings were collected, capturing how masculine, feminine, or neutral the noun was perceived to be. These scores served as the basis for evaluating whether grammatical gender systematically influences adjective production.

The model incorporated both fixed and random effects to account for participant variability and object characteristics. The independent variables included the grammatical gender with values masculine, feminine, and neutral (in German der, die, das), as well as the order of the adjectives (first, second, third) produced by each participant in describing each object. Furthermore, we considered the interaction between the grammatical gender and the order of the adjectives to take into account that the effect of the grammatical gender could be modified by the order of the adjectives. Importantly, the first adjective is understood to reflect the most immediate and spontaneous cognitive association, while the second and third adjectives tend to represent more deliberate and reflective judgments. Additionally, participants' gender and age (continuous variables) were included as independent variables in our analysis, given that this study investigates associations between grammatical and conceptual gender. It is plausible that participants' own biological sex, as well as generational differences reflected in age, could influence how they perceive and attribute gendered characteristics to objects. Including these variables allowed us to control for potential confounding effects in the analysis. Notably, the reference levels for the three categorical variables (Grammatical gender, order of the adjectives, the gender of the participant) in our model were set to *masculine* (in German *der*) for the grammatical gender, to *first* for the ordering of the adjectives being produced, and to *male* for participants' gender. In the analysis, a p-value < 0.05 was considered statistically significant.

The results of the linear mixed model for German monolinguals are summarized in Table 9. The study found no significant difference in the average score between female and male participants (b = −0.024, SE = 0.031, t (68.64) = −0.761, p = 0.449). Similarly, participant age did not have a significant effect (b = 0.002, SE = 0.002, t (78.38) = 1.277, p = 0.205). However, our analysis using a linear mixed model revealed a significant negative main effect for feminine grammatical gender (b = −0.434, SE = 0.181, t(29.28) = −2.405, p = 0.023), indicating nouns with feminine grammatical gender were described as more feminine than nouns with masculine grammatical gender. Conversely, no significant difference was found in the average score between the neutral and masculine grammatical genders (b = −0.243, SE = 0.181, t(29.38) = −1.346, p = 0.189). Regarding the adjective order, the average score for the second-mentioned adjectives was significantly lower than the first-mentioned adjectives (b = −0.135, SE = 0.045, t(4718.80) = −2.983, p = 0.003) and the same was true for third-listed adjectives (b = −0.114, SE = 0.046, t(4721.49) = −2.446, p = 0.014). This suggests that the second and third adjectives are more feminine than the first one, with a stronger effect for the second adjective. The study found significant interaction effects between the grammatical genders and the order of the adjectives. Notably, the average score for feminine grammatical gender described by the second adjective significantly increased (b = 0.240, SE = 0.064, t(4720.44) = 3.739, p < 0.001) as did that of the third adjective (b = 0.145, SE = 0.065, t(4720.23) = 2.214, p = 0.027), suggesting a relative shift toward more masculine-associated language with later adjectives in feminine noun contexts. Furthermore, for nouns with neutral grammatical gender, the average score associated with the second adjective significantly increased (b = 0.162, SE = 0.065, t (4719.37) = 2.477, p = 0.013), as did the average score for the third adjective (b = 0.136, SE = 0.067, t (4722.56) = 2.041, p = 0.041). Since all estimated coefficients for the interaction terms between grammatical gender and adjective order were statistically significantly different from zero, we conducted post-hoc tests to further explore the differences in the average scores between the grammatical gender categories within the order of adjectives.

To pinpoint the specific differences in the average score between the grammatical genders within the order of the above-mentioned adjectives, we conducted post-hoc tests, i.e. pairwise comparisons using z-tests. These were corrected with Holm's sequential Bonferroni (1979) procedure. An overview of the post-hoc results is given in Table 10. We found a significant difference between feminine and masculine grammatical gender for the first adjectives (d = −0.434, z = −2.405, SE = 0.181, p = 0.048), showing more feminine adjectives were used for feminine grammatical gender compared to masculine. This significant difference is only present in the first adjectives and no other pairs of grammatical genders showed any significant values.

The results of the linear mixed model for Farsi monolinguals are presented in Table 11. To critically examine the hypothesis of linguistic relativity, this study artificially imposed German grammatical gender categories onto the Farsi dataset. The rationale behind this approach was that, since Farsi is a genderless language, any grammatical gender effects found in German should not be replicated in Farsi. In this context, grammatical gender was

Table 9: Results of the linear mixed model for German monolinguals.

	b	SE	df	*t*-value	*p*-value
Intercept	4.085	0.141	43.114	28.886	< 0.001
GG = feminine	−0.434	0.181	29.279	−2.405	0.023
GG = neutral	−0.243	0.181	29.384	−1.346	0.189
Adjective order = second	−0.135	0.045	4718.795	−2.983	0.003
Adjective order = third	−0.114	0.046	4721.493	−2.446	0.014
Participant gender = female	−0.024	0.031	68.637	−0.761	0.449
Age (in years)	0.002	0.002	78.375	1.277	0.205
GG = feminine × adjective order = second	0.240	0.064	4720.435	3.739	< 0.001
GG = neutral × adjective order = second	0.162	0.065	4719.305	2.477	0.013
GG = feminine × adjective order = third	0.145	0.065	4720.276	2.214	0.027
GG = neutral × adjective order = third	0.136	0.067	4722.555	2.041	0.041

The linear mixed model is based on a total of 4808 observations from 74 participants. Both the participant's ID and the 30 objects to be described with an adjective were considered as random intercepts. b, estimated regression coefficient; SE, standard error; df, degrees of freedom; GG, grammatical gender. Marginal R^2, 0.0251, and Conditional R^2, 0.2354.

Table 10: Results of the post-hoc tests for German monolinguals.

Adjective order	Contrasts between GGs	*d*	SE	*z*-value	*p*-value
First	Masculine versus feminine	0.434	0.181	2.405	0.048
	Masculine versus neutral	0.243	0.181	1.346	0.356
	Feminine versus neutral	−0.191	0.181	−1.056	0.356
Second	Masculine versus feminine	0.194	0.181	1.071	0.852
	Masculine versus neutral	0.082	0.181	0.451	1.000
	Feminine versus neutral	−0.112	0.181	−0.619	1.000
Third	Masculine versus feminine	0.290	0.181	1.597	0.331
	Masculine versus neutral	0.107	0.182	0.590	0.629
	Feminine versus neutral	−0.183	0.181	−1.006	0.629

d, estimated mean difference; SE, standard error; GGs, grammatical genders.

included in the Farsi condition solely for purposes of cross-linguistic comparison, with German functioning as the experimental condition and Farsi as the control. To maintain methodological consistency and ensure comparability, the same stimulus groupings used in the German condition, based on grammatical gender (feminine, masculine, and neuter), were applied to the Farsi data. The objective was to investigate whether Farsi speakers, despite the absence of grammatical gender in their language, would nevertheless attribute similar gendered connotations to the stimuli as German speakers. Furthermore, to ensure analytical parity, the same fixed and random effects structure was retained across both language groups.

The study found no significant difference in the average score between female and male participants (b = 0.039, SE = 0.048, t(1612.723) = 0.805, p = 0.421). Similarly, participant age did not have a significant effect (b < 0.001, SE = 0.003, t(1612.782) = −0.147, p = 0.883). Consistent with the German data, feminine grammatical gender showed a significant negative effect in comparison to masculine grammatical gender, which also served as the reference category here (b = *−0.659*, SE = 0.272, t(31.817) = −2.421, p = 0.021). As with the German data, no significant effect was observed for the neutral grammatical gender. However, unlike the German data, the order of the adjectives did not have a significant effect in the Farsi dataset. Additionally, the interaction between the order of the adjectives and the grammatical gender was not significant.

To compare the German and Farsi data, we conducted the post-hoc tests following the same procedure used for the German data to maintain comparability in the analysis. These tests were adjusted using Holm's sequential Bonferroni (1979) correction as well to control for multiple comparisons. An overview of the post-hoc results is presented in Table 12. Pairwise comparisons were performed between the imposed grammatical gender

Table 11: Results of the linear mixed model for Farsi monolinguals.

	b	SE	df	*t*-value	*p*-value
(Intercept)	4.065	0.225	58.773	18.095	< 0.001
GG = feminine	−0.659	0.272	31.817	−2.421	0.021
GG = neutral	−0.145	0.277	33.909	−0.525	0.603
Adjective order = second	−0.161	0.093	1613.023	−1.727	0.084
Adjective order = third	0.006	0.096	1613.346	0.065	0.948
Participant gender = female	0.039	0.048	1612.723	0.805	0.421
Age (in years)	< 0.001	0.003	1612.782	−0.147	0.883
GG = feminine × adjective order = second	0.163	0.132	1612.360	1.234	0.217
GG = neutral × adjective order = second	0.151	0.149	1613.321	1.016	0.310
GG = feminine × adjective order = third	0.033	0.135	1612.502	0.240	0.810
GG = neutral × adjective order = third	−0.153	0.149	1614.416	−1.023	0.306

The linear mixed model is based on a total of 1648 observations from 65 participants. Both the participant's ID and the 30 objects to be described with an adjective were considered as random intercepts. *b*, estimated regression coefficient; SE, standard error; df, degrees of freedom. Marginal R^2, 0.0562 and conditional R^2, 0.3012.

Table 12: Results of the post-hoc tests for Farsi monolinguals.

Adjective order	Contrasts between GGs	*d*	SE	*z*-value	*p*-value
First	Masculine versus feminine	0.659	0.272	31.013	0.065
	Masculine versus neutral	0.145	0.277	33.054	0.603
	Feminine versus neutral	−0.514	0.278	33.347	0.146
Second	Masculine versus feminine	0.496	0.273	31.429	0.237
	Masculine versus neutral	−0.006	0.277	33.261	0.983
	Feminine versus neutral	−0.502	0.278	33.417	0.237
Third	Masculine versus feminine	0.627	0.274	31.878	0.087
	Masculine versus neutral	0.298	0.277	33.159	0.488
	Feminine versus neutral	−0.329	0.277	33.221	0.488

d, estimated mean difference; SE, standard error; GGs, grammatical genders.

categories on the Farsi data for each level of adjective order separately. Unlike the German data, no significant differences were found between grammatical gender categories across the different adjective orders in the Farsi dataset.

These results underscore the influential role of grammatical gender in shaping the conceptualization and categorization of objects among German speakers, as reflected in the adjectives they produce – particularly those mentioned first. The significant interaction between grammatical gender and adjective order further suggests that grammatical gender influences cognitive processing and guides the sequence of adjective selection. In contrast, the Farsi data did not exhibit a comparable pattern, showing no significant interaction between adjective order and the imposed grammatical gender. Moreover, post-hoc analyses revealed no significant differences between any grammatical gender categories in the Farsi condition, reinforcing the absence of grammatical gender effects in this genderless language.

5 Discussion

5.1 The discussion organized by research questions

5.1.1 Does the grammatical gender of the nouns influence the assignment of properties to objects and animals by German native speakers?

The findings indicate that the grammatical gender of nouns may subtly influence how monolingual German speakers assign descriptive properties to objects and animals. In the German dataset, significant main effects emerged for adjective order (i.e., first, second, and third position), as well as a significant interaction between grammatical gender and adjective order (see Table 9). Notably, this interaction was driven primarily by feminine stimuli, for which the effect of adjective order was strongest. Post-hoc pairwise comparisons confirmed that this effect was most robust for the first adjective produced, revealing a statistically significant contrast between nouns with masculine and feminine grammatical gender (see Table 10). Specifically, the first adjective selected by participants consistently aligned with the grammatical gender of the referent noun, suggesting that grammatical gender can shape immediate, automatic conceptual associations. This pattern aligns with the notion of a primacy effect (Asch 1946), whereby early responses are more susceptible to implicit linguistic structures, preceding more reflective or individualized judgments.

In contrast, second and third adjectives showed no significant gender-based differences, which may reflect participants' increased reliance on personal associations or object familiarity as the task progressed. This pattern is in line with prior research demonstrating that grammatical gender activates early and unconsciously during language processing, even in the absence of explicit gender judgments (Boutonnet et al. 2012; Sato et al. 2020). Importantly, our use of a free description task, as opposed to explicit gender labeling or voice assignment, further

strengthens the conclusion that participants were not consciously focused on grammatical gender, yet it still guided their responses in systematic ways.

A particularly novel contribution of our study lies in the inclusion and treatment of neuter grammatical gender as an independent category. Although the post-hoc tests for neuter-gender nouns yielded no statistically significant differences, this outcome aligns with our hypothesis. Adjectives in the range (3,5] were defined as neutral traits, while [1,3] and (5,7] were associated with feminine and masculine traits, respectively. We anticipated – and confirmed – that neutral nouns would not differ meaningfully from either masculine or feminine nouns in gendered associations. The lack of significant contrast supports the interpretation that German speakers categorize neuter-gendered objects as conceptually neutral, rather than interpreting them as implicitly masculine or feminine by default. The lack of significance is thus meaningful: it reflects a psychologically real and conceptually distinct category. In this way, the grammatical structure of German appears to support a three-way gender conceptual framework, rather than forcing binary categorization. Moreover, participants' age and sex did not significantly influence the results, which suggests that these patterns are not driven by demographic variation, but likely reflect structural effects of the German language system itself.

This interpretation strengthens earlier findings from studies on three-gender languages such as Polish and Norwegian, which show that grammatical gender effects are not limited to binary gender systems (Beller et al. 2015; Boroditsky et al. 2003; Haertlé 2017; Maciuszek et al. 2019; Sedlmeier et al. 2016).

Compared to earlier studies that used explicit gender cues, such as assigning voices or requiring gender categorization (e.g., Almutrafi 2015; Athanasopoulos and Boutonnet 2016), our open-ended description task offered a more naturalistic context for uncovering the effects of grammatical gender. Importantly, we observed these effects without drawing participants' attention to gender, which enhances the ecological validity of our findings. That the gender alignment appeared primarily in the first adjective strongly suggests automatic activation of grammatical gender.

We also improved upon previous designs by including a larger and more diverse participant pool in the second phase of the study. Participants evaluated adjectives on a 7-point Likert scale, enabling a more fine-grained, continuous measurement of gender associations than binary tasks typically allow (e.g., Boroditsky et al. 2003; Sedlmeier et al. 2016). This methodological expansion increased both reliability and interpretive richness.

Most crucially, our treatment of neutral grammatical gender as a fully integrated category, rather than excluding it or collapsing it into binary groupings – offers a key theoretical contribution. Studies that do include neuter terms often force binary judgments (e.g., Bender et al. 2018), but our approach treated neuter gender as conceptually independent. The finding that neuter nouns elicited neutral trait ratings supports the view that German speakers treat them not as ambiguous or default categories but as conceptually distinct. This opens a path for cognitive-linguistic research to move beyond binary models of gender representation.

In theoretical terms, our findings suggest that grammatical gender systems do more than highlight male/female distinctions – they can also encode a third, non-binary conceptual category. This expands current understandings of linguistic relativity by demonstrating that gender effects are not inherently dichotomous and may instead reflect the specific structural affordances of a language. It challenges the assumption that gendered cognition always maps onto binary categories and supports a more typologically inclusive perspective.

5.1.2 Do Farsi native speakers differ from German native speakers in assigning properties to objects and animals?

The analysis demonstrates that Farsi monolingual speakers did not exhibit systematic differences in the adjectives they assigned based on the grammatical gender categories imposed by German. A significant effect emerged for feminine nouns in the model ($p = 0.021$). However, neutral nouns, adjective order, and the interaction between grammatical gender and adjective order were not significant. Post-hoc analyses of the Farsi data (Table 12), using the same procedure as for German, did not reveal any significant pairwise differences between grammatical gender conditions across adjective positions.

Although a main effect appeared in the overall model, this may reflect variability introduced during noun selection. However, the selection process was not guided by any intention to bias conceptual gender; as described in the Materials section, stimuli were chosen based on pre-established criteria unrelated to gender connotation. No consistent or interpretable differences emerged between gender groups. We interpret this as evidence that the gender structure of the German stimuli does not exert a systematic influence on adjective selection in Farsi. This contrasts with the German data, where grammatical gender significantly influenced the assignment of properties, particularly in the first adjective position. In Farsi, no significant main effects were found for participant sex or age, nor for the order of adjective responses. Furthermore, no interaction was observed between the imposed grammatical gender categories and adjective order. These findings support the hypothesis that grammatical gender, as a structural feature of language, exerts an influence on conceptualization, one that is absent when such a feature is not grammatically encoded.

Importantly, although German grammatical gender categories were artificially overlaid onto the Farsi dataset to ensure analytical comparability, the absence of corresponding effects underscores the role of grammatical gender as a genuine cognitive cue for German speakers. The imposed categories did not trigger differentiated responses among Farsi speakers, which reinforces the idea that these effects are not driven by universal semantic associations, but rather by the grammatical structures embedded in the speaker's native language. This lack of a grammatical gender effect in Farsi aligns with earlier findings in other genderless languages such as Tamil (Sedlmeier et al. 2016), further corroborating the structuralist interpretation of linguistic relativity.

The difference between the two language groups offers empirical support for the idea that speakers of languages with grammatical gender (such as German) develop automatized cognitive associations that subtly shape perception, even when gender is not explicitly attended to. In contrast, speakers of genderless languages (such as Farsi) are unlikely to spontaneously map objects to gendered traits in the absence of such cues. The fact that the Farsi participants' ratings remained stable across the adjective positions further supports the conclusion that their responses were not influenced by linguistic structure but were instead guided by individual semantic associations or subjective interpretations of the visual stimuli.

Moreover, while the German results showed evidence of a primacy effect (Asch 1946), where the first adjective aligned with grammatical gender more strongly, this pattern was absent in the Farsi data. This strengthens the claim that grammatical gender in German functions as a cognitive cue that becomes automatically activated early in the response process. In Farsi, where no such grammatical scaffolding exists, the response pattern lacked this early bias.

Together, these findings provide cross-linguistic evidence for the principle of linguistic relativity: structural features of language can shape habitual thought in ways that are both automatic and language-specific. The contrast between German and Farsi offers a compelling demonstration of how the presence or absence of grammatical gender affects conceptualization at a subtle level, especially in contexts where participants are not explicitly prompted to think in gendered terms. By placing these two languages at opposite ends of the grammatical gender spectrum (Fatemi 2023), the study reveals how deep-seated structural features can influence even simple descriptive tasks.

6 Conclusions

This study underscores the critical importance of developing robust methodological frameworks to investigate how grammatical gender influences cognition. By systematically including all grammatical gender categories – especially the often-overlooked neutral gender in German – our findings provide nuanced insights into the ways linguistic structures shape thought. Furthermore, expanding research to include understudied languages like Farsi enriches our understanding of linguistic relativity across diverse linguistic and cultural contexts.

Several limitations warrant consideration. While high-frequency words were carefully selected to maintain relevance, excluding animate nouns might have further refined the stimuli. Additionally, the shift between online and pen-and-paper data collection due to logistical constraints was managed carefully to preserve data integrity, although such procedural adjustments should be noted in interpreting the results.

Our findings contribute both theoretically and empirically. Theoretically, they reinforce and extend linguistic relativity by demonstrating how the presence or absence of grammatical gender influences conceptualization, highlighting a three-way gender framework in German and the absence of such effects in genderless Farsi. Empirically, these insights offer valuable implications for gender studies, language acquisition, and cognitive psychology, informing efforts to design gender-sensitive research, improve language teaching strategies, and deepen cross-cultural understanding of cognition.

Overall, this research advances interdisciplinary inquiry into the cognitive effects of grammatical structures, providing a foundation for future studies to explore the complex interactions between language, thought, and culture.

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Author contributions: All authors have accepted responsibility for the content of this manuscript and approved its submission. MF and BM designed the experiments; MF conducted the experimental work. The initial statistical model was developed by MF in collaboration with the Statistical Consulting and Analysis Department at the Centre for Higher Education at TU Dortmund University. VS assisted with the statistical modeling incorporated into the revised manuscript following reviewer feedback. MF prepared the final manuscript with getting consultation from all co-authors.
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Data availability statement: The datasets generated and/or analyzed during the current study are available in the Open Science Framework repository and can be accessed at https://osf.io/qmsbh.

Appendix A: Survey instructions and test design

The following instructions were provided to participants at the start of the test:

Phase 1: German instructions:

„Liebe Teilnehmerinnen und Teilnehmer, Herzlich willkommen! In dieser Studie sollen Sie kurz Fragen beantworten, die sich auf darunterstehende Bilder beziehen. Für manche Fragen müssen Sie die Bilder beschreiben, indem Sie spontan die ersten drei Adjektive aufschreiben, die Ihnen in den Sinn kommen. In anderen Fragen werden Sie gebeten, spontan die Uhrzeit anzugeben. Ihre Antworten werden streng vertraulich behandelt. Haben Sie herzlichen Dank für Ihre Zeit und Ihr Interesse! Um die Umfrage zu öffnen, akzeptieren Sie bitte unsere Datenschutzerklärung."

Translation:

Dear participants, welcome! In this study, you will be asked to briefly answer questions relating to the images below. For some questions, you will describe the images by spontaneously writing down the first three adjectives that come to mind. In other questions, you will be asked to spontaneously indicate the time. Your answers will be kept strictly confidential. Thank you very much for your time and interest! To begin the test, please click on the provided link to confirm your participation and proceed with the tasks.

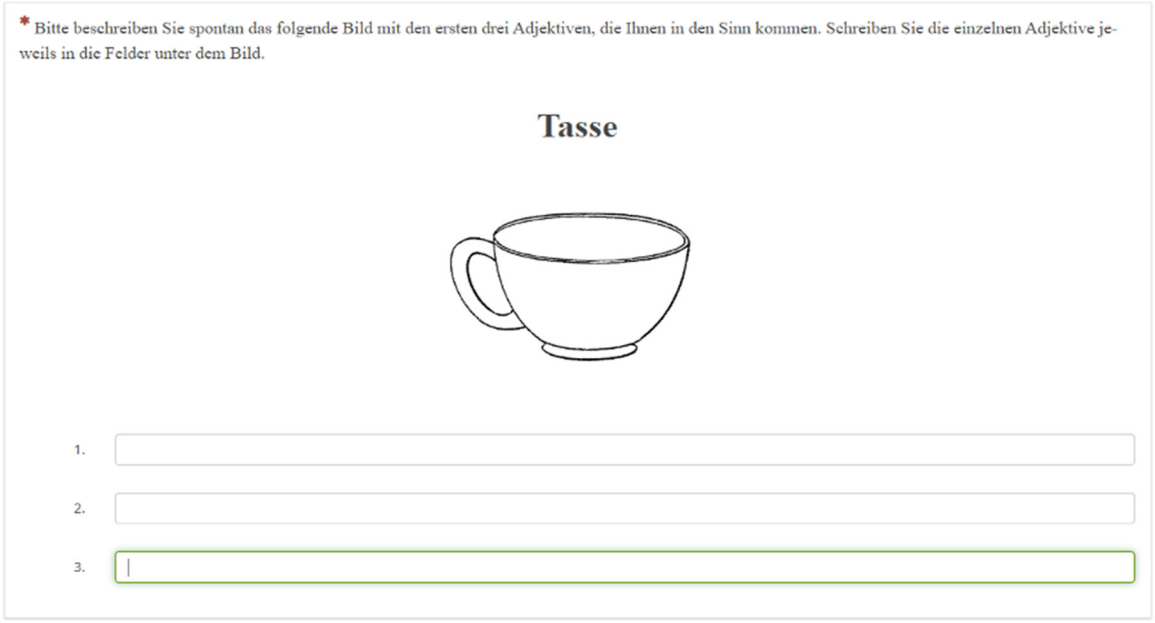
Test prompt (after instructions):

Participants were guided to the main task with the following prompt:

„Bitte beschreiben Sie spontan das folgende Bild mit den ersten drei Adjektiven, die Ihnen in den Sinn kommen. Schreiben Sie die einzelnen Adjektive jeweils in die Felder unter dem Bild.“

Translation:

Please describe the following image spontaneously with the first three adjectives that come to mind. Write each adjective in the fields below the image.



Phase 2: Gender assignment

“Liebe Teilnehmerinnen und Teilnehmer, in dieser Phase bitten wir Sie, den folgenden Adjektiven ein Geschlecht zuzuordnen. Bewerten Sie das Adjektiv auf einer Skala von 1 bis 7:1 = sehr feminin, 7 = sehr maskulin.”

Translation

Dear participants, in this phase, we ask you to assign a gender to the following adjectives. Please rate each adjective on a scale from 1 to 7: 1 = very feminine, 7 = very masculine.

Appendix B

See Tables A1–A3.

Table A1: List of feminine-stimuli item and images.

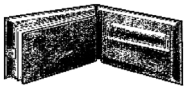
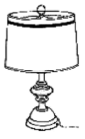
1	Ente	
2	Taube	
3	Fliege	
4	Schildkröte	
5	Blume	
6	Börse	
7	Tasse	
8	Lampe	
9	Gruppe	
10	Uniform	

Table A2: List of masculine-stimuli item and images.

1	Hund	
2	Zeh	
3	Pinguin	

Table A2: (continued)

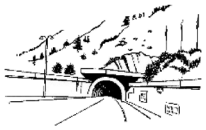
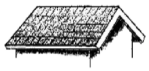
4	Ball	
5	Bus	
6	Fuß	
7	Tunnel	
8	Brunnen	
9	Zaun	
10	Globus	

Table A3: List of neutral-stimuli item and images.

1	Huhn	
2	Eichhörnchen	
3	Ziel	
4	Herz	
5	Feuer	
6	Netz	

Table A3: (continued)

7	Dach	
8	Geschenk	
9	Gepäck	
10	Getränk	

Appendix C

See Table A4.

Table A4: Frequency class table by the psycholinguistics laboratory of TU Dortmund University using Ruhr University Bochum's method.

Frequency class	Min	Max
0	230188366	325535509
1	115094183	230188365
2	57547092	115094182
3	28773546	57547091
4	14386773	28773545
5	7193387	14386772
6	3596694	7193386
7	1798347	3596693
8	899174	1798346
9	449587	899173
10	224794	449586
11	112397	224793
12	56199	112396
13	28100	56198
14	14050	28099
15	7025	14049
16	3513	7024
17	1757	3512
18	879	1756
19	440	878
20	220	439
21	110	219
22	55	109
23	28	54
24	14	27
25	7	13
26	4	6
27	2	3
28	1	1

Appendix D

Lexeme-specific variability in both the German and Farsi datasets (Figures 2–2.5).

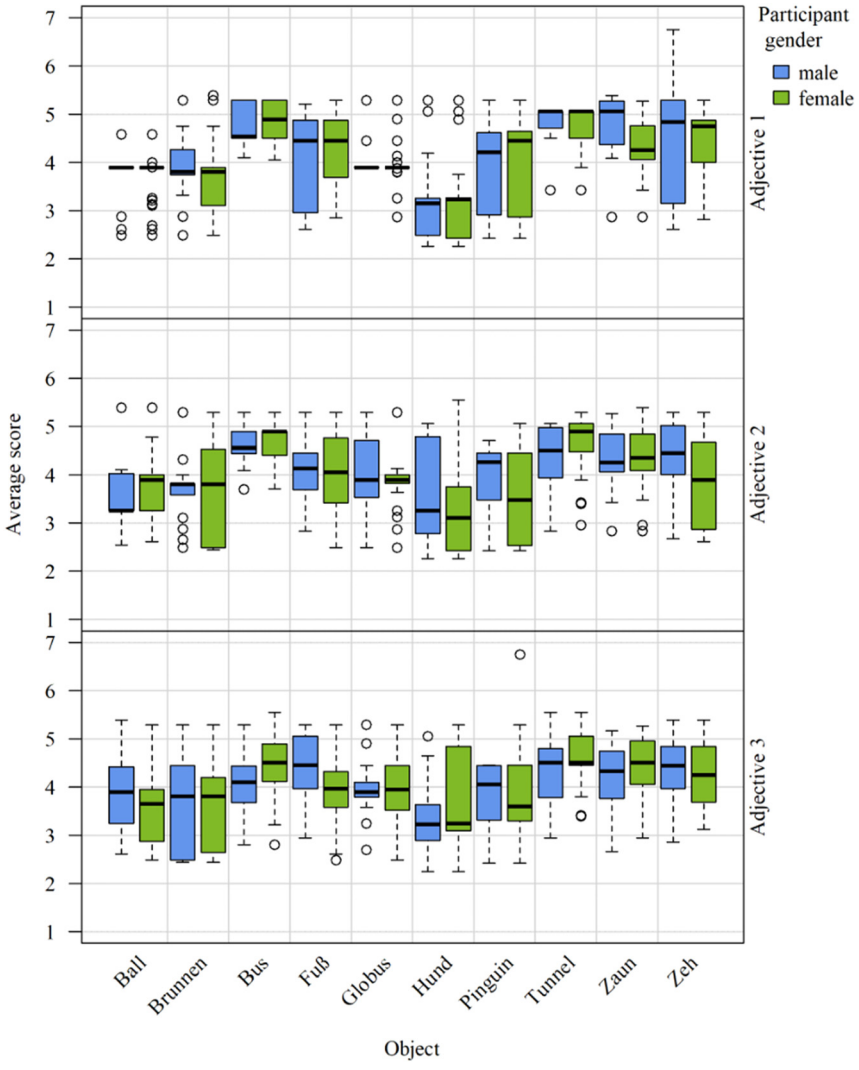


Figure 2: Boxplots of the mean adjective scores separated by participant gender and repetition for the M-stimuli objects (German participants).

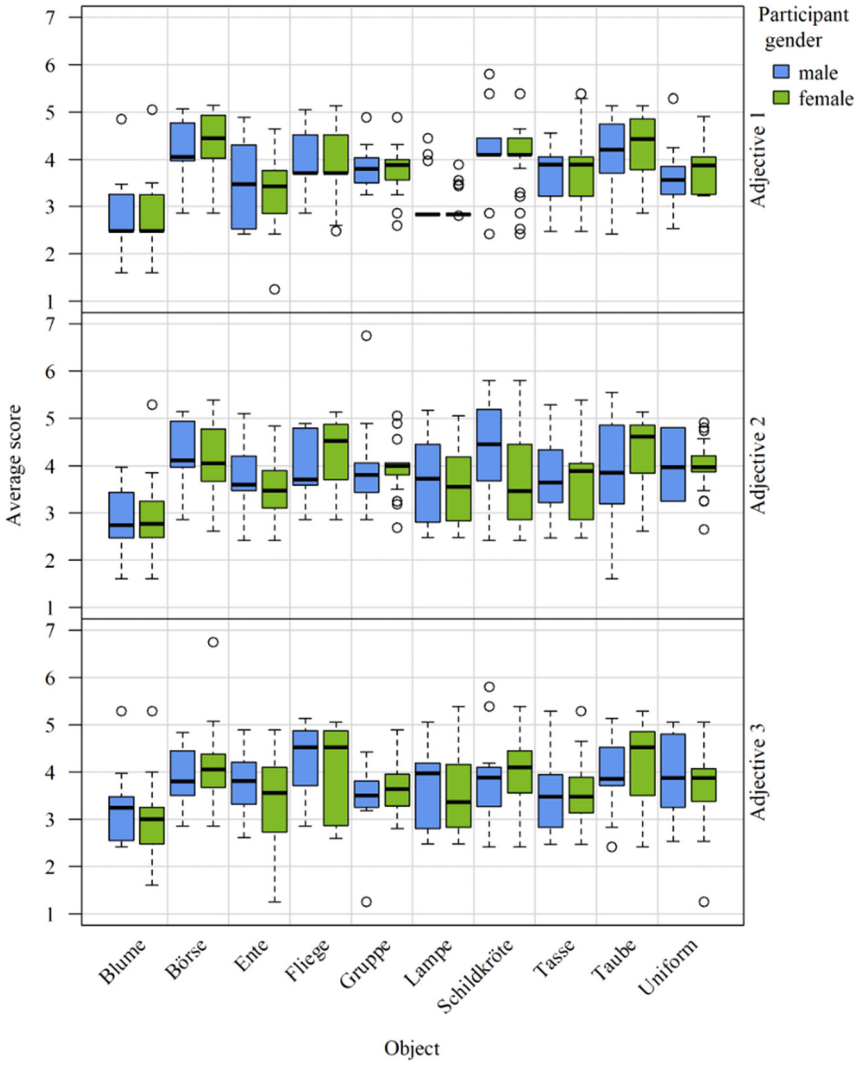


Figure 2.1: Boxplots of mean adjective scores by participant gender and repetition for F-stimuli objects (German participants).

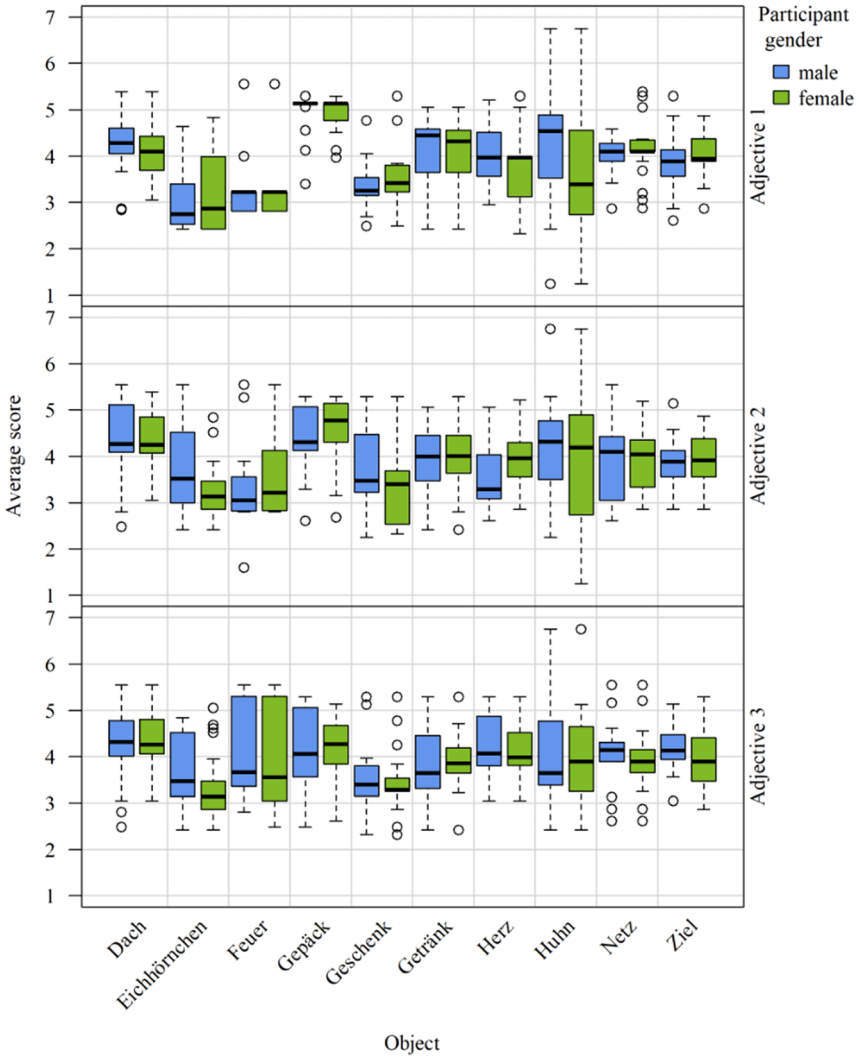


Figure 2.2: Boxplots of mean adjective scores by participant gender and repetition for N-stimuli objects (German participants).

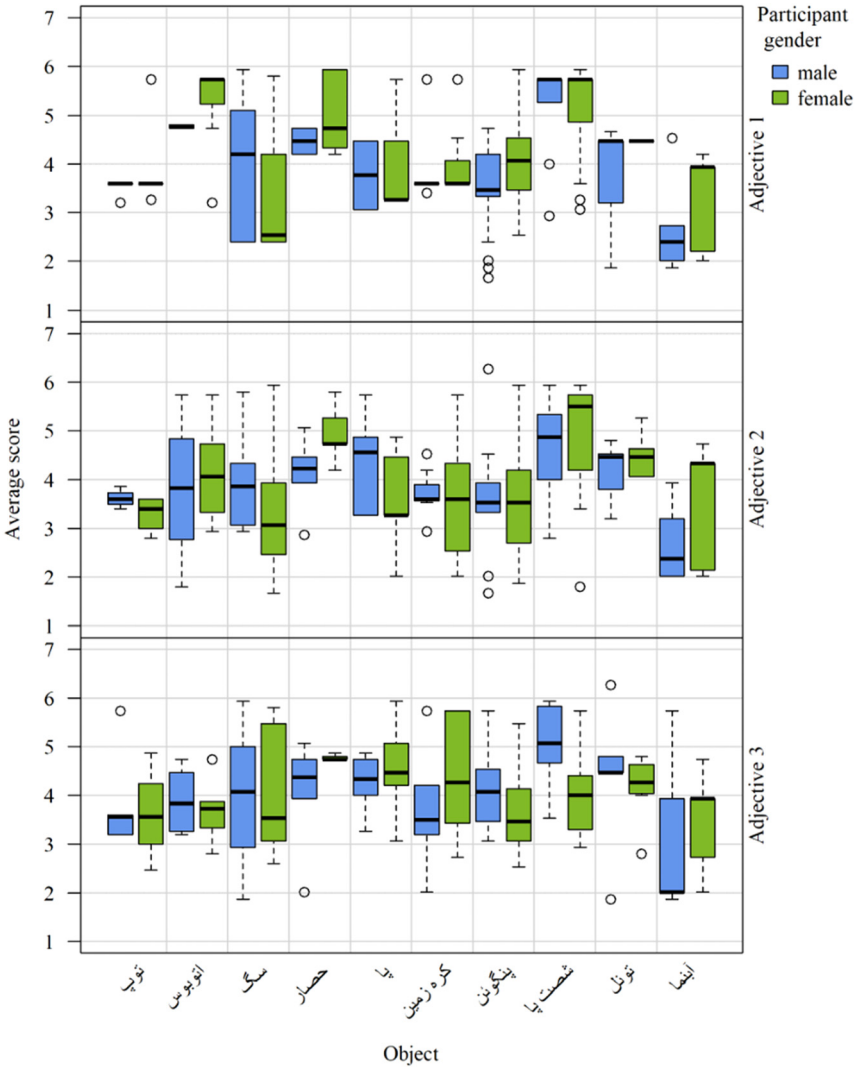


Figure 2.3: Boxplots of the mean adjective scores by participant gender and adjective order for the M-stimuli objects, based on German grammatical gender (Farsi participants). Word translations from left to right: ball, bus, dog, fence, foot, globe, penguin, toe, tunnel, fountain.

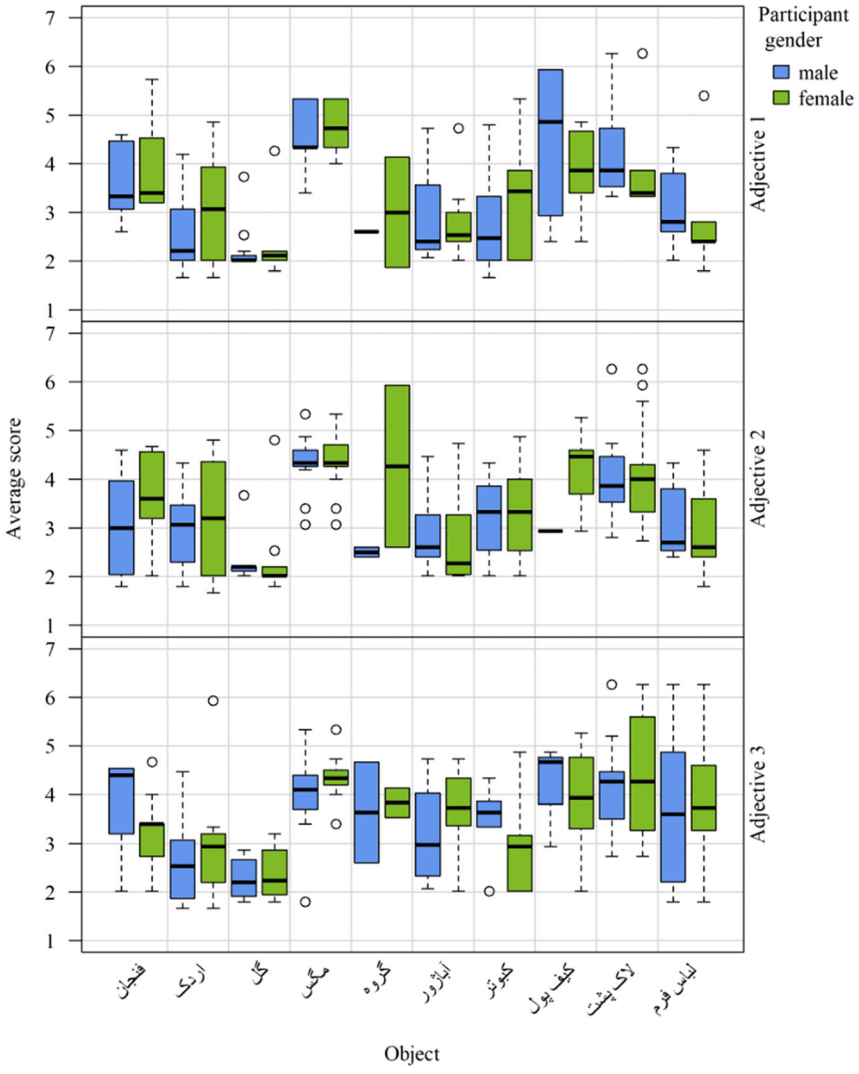


Figure 2.4: Boxplots of the mean adjective scores by participant gender and adjective order for the F-stimuli objects, based on German grammatical gender (Farsi participants). Word translations from left to right: cup, duck, flower, fly, group, Lamp, pigeon, wallet, turtle, uniform.

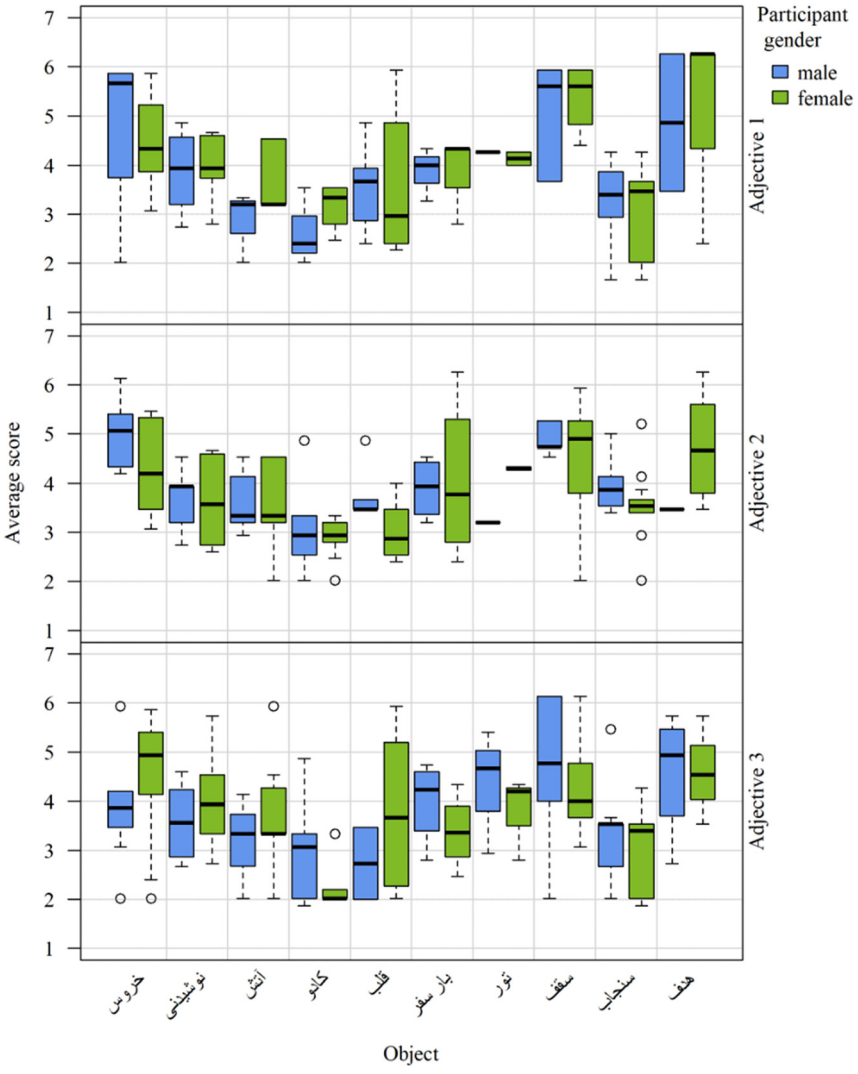


Figure 2.5: Boxplots of the mean adjective scores by participant gender and adjective order for the N-stimuli objects, based on German grammatical gender (Farsi participants). Word translations from left to right: rooster, drink, fire, gift, heart, luggage, net, roof, squirrel, goal.

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