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Bidialectal language representation and processing: Evidence from Norwegian ERPs

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ABSTRACT

This study investigates bilectal grammatical representation and processing using three ERP reading experiments in two Norwegian dialect regions. Northern Norwegian bilectals were tested in two separate sessions in two written varieties: the local written standard (Bokmål, n = 83) and Northern Norwegian dialect writing (n = 68). The study included both non-contrastive gender (control) and dialect-specific number (target) agreement conditions. In grammatically incongruent number conditions, participants display contrasting processing profiles in both on-line and off-line measures (reversed P600 components and reversed grammaticality judgments). To further test the interaction between contrasting bilectal grammars in language processing, the Bokmål version of the experiment was also conducted in a second dialect region (Sunnmøre, n = 73) where the spoken dialect is grammatically aligned with Bokmål for both gender and number. In the Bokmål mode, compared to both the control group (Sunnmøre) and the control condition (gender agreement), Northern Norwegian participants in the target (number) condition show significantly attenuated ERPs and more gradient and less accurate grammaticality judgments, evidencing competition between distinct bilectal grammatical representations. The results further revealed significant individual differences in the degree of cross-dialectal influence between Bokmål and Northern Norwegian dialect modes, contingent on individual participants' bilectal engagement and exposure. Together these results suggest that bilectalism is a proper sub-case of bilingualism: bilectals develop distinct grammatical representations for contrastive grammatical features in distinct L1 varieties with which they have sufficient engagement and exposure.

Background

This study investigates bilectalism/bidialectalism, and how prolonged exposure to and engagement with narrow grammatical variation in one's L1 may influence L1 linguistic representations and grammatical processing. Bilectalism refers to contexts where individuals — *bilectals* — have acquired two (vernacular) varieties (e.g., Northern and Western Norwegian dialects) and/or one or more written varieties of the same language (e.g., Norway's two official written languages, Nynorsk and Bokmål). As illustrated in (1), bilectals acquire linguistic systems which are alike in most domains but which can vary in lexicon, phonology (e.g., contrastive segmental representations: *ej/æ/jeg/eg*, *tro-/tru-*, *var/va*, *ikke/ikkje*, etc.), and/or morphology and morphosyntax (e.g., non-/encliticisation: *tror ikkje/truk(j)e*; differing

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allomorphy: *-ane*, *-an*, *-ene*; presence/absence of predicate number agreement marking: *stor-e* vs. *stor-*; etc.).

(1) **Lexical and grammatical variation in Sunnmøre Norwegian, Northern Norwegian, Bokmål, and Nynorsk**

ej	trukje		hund-ane	va	så	stor-e	**Sunnmøre Norwegian**
æ	tror	ikkje	hund-an	va	så	stor_	**Northern Norwegian**
jeg	tror	ikke	hund-ene	var	så	stor-e	**Bokmål**
eg	trur	ikkje	hund-ane	var	så	stor-e	**Nynorsk**
I	believe	not	dog-DEF.(M.).PL.	were	so	big-PL./∅	

"I do not think the dogs were so big."

Despite the obvious similarities between cross-dialectal and cross-linguistic variation (Chevrot & Ghimenton, 2018; Grohmann et al., 2016), dialect differences like (1) are in many respects quite different from other forms of multilingualism (Leivada et al., 2017; Lundquist & Vangsnes, 2018; Melinger, 2018; Ross & Melinger, 2016; Xie & Zhong, 2023). Given the typological proximity of the varieties involved, the degree of grammatical differences between dialects is typically smaller, and in many cases will not (at least as significantly) impede intelligibility compared to bilingual contexts. Moreover, there are often significant differences in language use in bilingual and bilectal contexts; a bilectal might be highly exposed to another dialect due to relocation or regular interaction, yet never actively speak it, creating pronounced asymmetries in exposure/comprehension and engagement/production. Given these differences in language use context, lesser linguistic contrastivity, and more limited relevance for listener comprehension, it is not obvious whether and to what extent language users — given sufficient engagement and exposure — develop distinct bilectal linguistic representations and differentially process contrasting dialectal varieties of their L1.

The majority of neurolinguistic work on bilectal processing has so far focused on phonetic/phonological and semantic processing (e.g., Bühler et al., 2017; Goslin et al., 2012; Lanwermeyer et al., 2016; Martin et al., 2016). Research on bilectal (morpho)syntactic processing has been much more limited and has yielded mixed results. For example, Garcia (2017) and Garcia et al. (2022) compared ERP responses to African American English-specific and non-specific morphosyntactic conditions — specifically, AAE maintained verb forms in present progressive sentences (e.g., *the black cat lap/s the milk*). Contrasting Mainstream American English (MAE) speakers and African American English (AAE) bilectals, they found that monolectal MAE speakers show P600 effects associated with AAE maintained verb constructions while AAE/MAE bilectals show no ERP responses in the same conditions. Using a similar design, Kubota et al. (2023) studied gender and number agreement processing among two groups of Norwegians, those born and raised in Northern Norway and those from other parts of Norway who later relocated to the North. The data reveal that P600 effects of Northern-specific number zero-marking among the relocated group were significantly modulated by individual engagement with and exposure to Northern Norwegian dialects. Finally, Zaharchuk et al. (2021) investigated Southern U.S. English (SUSE) double modal (e.g., *she might could come*) and MAE single modal constructions among speakers with and without familiarity with SUSE, finding significant group differences in off-line acceptability judgments but no corresponding differences in ERPs.

As a whole, these initial studies provide a rather ambiguous picture and their interpretation is not straightforward. Each study has tested grammatical processing in only one dialect and/or has not separately tested distinct dialect modes in separate sessions (using single dialect or single speaker stimuli). In other words, so far only monolectal processing (albeit with cross-dialectally varying violations) among distinct dialect groups has been investigated, leading to potential confounds. For example, although Kubota et al. (2023) show that relocated Non-Northern dialect speakers exhibit more Northern-like ERP responses as their engagement/exposure to Northern Norwegian increases (similar to L2 acquisition; e.g., Alemán Bañón et al., 2018), these speakers were not tested in their native dialect. As such, it is unclear if these results actually reveal acquisition of a secondary dialect grammar (bilectalism) or alternatively only that their native (monolectal) dialect representations have shifted in response to changing dialect exposure (e.g., akin to category shifting, Bybee, 2012; Todd et al., 2019). Similarly, Garcia et al. (2022) has shown that MAE- and AAE-speaking groups show dissimilar responses to AAE-specific features, but to what extent MAE/AAE bilectals have distinct linguistic representations for each variety remains to be seen. Finally, Zaharchuk et al. (2021) found no difference in ERP responses to SUSE-specific features between SUSE-familiar and SUSE-unfamiliar groups. However, participants evaluated the speaker stimuli as having no accent (Zaharchuk et al., 2021, §2.2.1), which is not unsurprising as the stimuli were designed to limit the effect of dialect-specific phonetic and prosodic characteristics. In the absence of dialect-specific cues, it remains unclear to what extent the stimuli would activate bilectals' SUSE-specific morphosyntax.

In response to the issues outlined above, the present study introduces three ERP experiments to test cross-dialectal processing in two Norwegian varieties — Northern Norwegian dialect and the standard written variety Bokmål — the latter of which is additionally conducted in two dialect regions (Northern Norway and Sunnmøre [Western Norway]) whose dialects display varied grammatical congruency with Bokmål (Fig. 1). To test the effect of bilectal in/congruency on grammatical processing directly, this study incorporates both cross-dialectally varying (target) and non-varying (control) grammatical conditions, outlined in further detail in the materials and design section. By integrating ERP measures and acceptability judgment tasks, conducted in two variety modes and in two dialect regions, with comprehensive questionnaire data on individual bilectal engagement and exposure, we aim to achieve a more precise understanding of (i) how bilectals adapt to narrow grammatical variation across native varieties, (ii) to what extent bilectals acquire distinct grammatical representations for distinct L1 varieties with which they have sufficient exposure, and (iii) how bilectal representations and processing may be influenced by individual differences in bilectal linguistic experience and the level of grammatical dis/similarity between varieties.

The Norwegian linguistic landscape, where bilectalism is a universal, characterizing phenomenon, offers a particularly valuable context for bilectal research (Kubota et al., 2023). In contrast to other areas where the majority of bilectalism research has been conducted (e.g., USA, UK, Germany, etc.), Norway lacks a standardized spoken dialect, and the use of regional dialects in all areas of one's life (including, e.g., national media) is the norm (Leon, 2014; Røyneland, 2009, 2020) — contributing to regular exposure to other spoken dialects. Moreover, in the written domain, Norway features two official (non-spoken) written varieties, Nynorsk and Bokmål (1), which all students — with well-described exceptions – are required to learn (choosing one as their main vs. secondary/non-primary written language; Education Act, § 2.5). Finally, especially in regional parts of Norway, in addition to Bokmål and Nynorsk, there is also regular use of so-called *dialect writing* (1) — a non-conventional local written form of speakers' dialect which represents dialect-specific lexical, phonological, and morphosyntactic traits, commonly used in social media, texting, and other informal contexts (Hårstad, 2021; Røyneland & Vangsnes, 2020; Vangsnes, 2019). In sum, the default scenario of obligatory (written) bilectal education and decentralization of dialect usage qualifies virtually all Norwegians as bilectals, irrespective of socioeconomic status (SES) and other SES-related factors that are otherwise often difficult to disentangle from dialect use in other contexts, allowing us to better isolate the specific effects of bilectalism on language processing. For

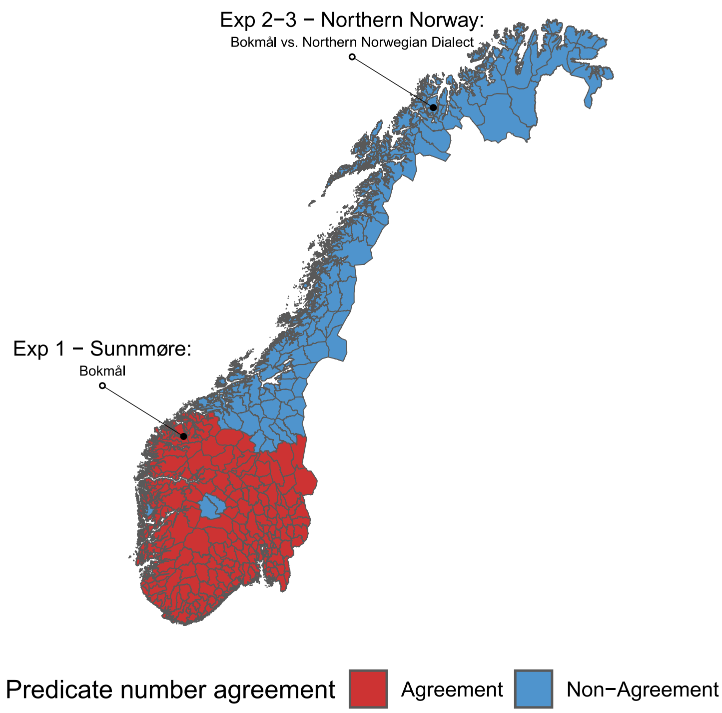

Fig. 1. Bilectal test sites with color indicators illustrating the distribution of the study's target condition — predicate adjectival plural number agreement — based on Sandøy (1988)'s dialectal surveys: *Experiment 1* — Sunnmøre: Bokmål mode; *Experiment 2* — Northern Norway: Bokmål mode; *Experiment 3* — Northern Norway: Northern Norwegian dialect mode. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

a more detailed overview of the Norwegian language context, please refer to our supplementary material available at our public OSF site.

By leveraging Norway's unique multilectal context, the primary goal of our study is to achieve clearer insights into the nature of bilectalism and how exposure to and engagement with narrow grammatical variation in one's language influences sentence processing in bilectal contexts. Our study design includes both on-line processing measures (ERPs) and off-line behavioral measures (acceptability judgments) to distinguish two anticipated competing possible outcomes. First, it may be that speakers only distinguish between two varieties, or two grammatical variants, if they differ to a certain extent. If the grammatical differences are minimal, such as the number agreement marking in Bokmål and Northern Norwegian dialect (1), it might be that speakers do not develop distinct grammatical representations. Instead, they may rely on meta-linguistic knowledge of differences between their native-spoken dialect and Bokmål to apply appropriate grammatical rules when switching between writing in Bokmål and speaking in their dialect. In this scenario, we might expect to see potential differences in behavioral results (contrasting grammaticality judgments between Bokmål and Northern Norwegian dialect modes), representing meta-linguistic awareness of the differences between the two, but no differences in their ERPs, representing automatic parsing based in their L1-dialectal grammar. On the other hand, if bilectals do acquire distinct dialect-specific grammatical representations, even for relatively narrow cross-dialectal differences, then we *a priori* expect to see contrasting Bokmål/Northern Norwegian results in both on-line and off-line measures, modulated by individual bilectal experience (cf., Kubota et al., 2023; Zaharchuk et al., 2021).

Individual variability is a significant aspect of this study. Research has shown that individual linguistic experience (e.g., language engagement/exposure, dominance, etc.) significantly influences bilingual language processing, both among simultaneous/heritage bilinguals as well as adult L2 learners (e.g., Caffarra et al., 2017, 2015; van Dijk et al., 2022; Dussias et al., 2015; Martohardjono et al., 2017). Similarly, the aforementioned studies on dialect processing (Kubota et al., 2023; Zaharchuk et al., 2021) reveal that individual engagement with and exposure to a second dialect significantly influences dialect-specific processing. To assess how individual dialect experience modulates bilectal processing, we adapted Language Social Background Questionnaires (outlined in further detail in the methods section) to measure degrees of engagement/exposure to speakers' language(s), dialect(s), and Bokmål. This approach allows us to obtain detailed continuous measures of individual linguistic experiential effects on processing cross-dialectally contrastive and non-contrastive grammatical patterns. Through this comprehensive approach which incorporates both between- and within-subject designs, testing both cross-dialectally grammatically congruent and incongruent conditions in two variety modes and in two dialectal regions, we aim to provide better resolution on the intricate dynamics of bilectal language processing and its parallels to bilingual processing.

Methods

Materials and design

The present study consists of three ERP reading comprehension experiments conducted in two variety modes and in two dialect regions (Experiment 1: Sunnmøre–Bokmål; Experiment 2: Northern Norway–Bokmål; Experiment 3: Northern Norway–Northern Norwegian dialect). These experiments represent a close replication of the Northern Norwegian study employed by Kubota et al. (2023), using the same experimental design but with dissimilar fillers and expanded to encompass both Northern Norwegian dialect and Bokmål modes. All stimuli, questionnaires, data, and analysis scripts can be found on the following public OSF repository.[1]

Participants from Northern Norway underwent testing in two distinct sessions, one for Bokmål and a second for Northern Norwegian dialect, with a minimum interval of a week between sessions. Sunnmøre participants were tested in a single session and exclusively in the

[1] https://osf.io/htjxw/?view_only=5f9df38c10b747e4945f977f5f84eeef

Table 1
Gender and number non-/agreement grammaticality in Bokmål, Sunnmøre Norwegian, and Northern Norwegian (✓ = grammatical; × = ungrammatical).

Condition	Agreement	Example	Bokmål	Sunnmøre Norw.	Northern Norw.
Adj.gen	agr.	*eleven var frekk*	✓	✓	✓
	non-agr.	*eleven var frekt*	×	×	×
Adj.num	agr.	*husene var fine*	✓	✓	×
	non-agr.	*husene var fin*	×	×	✓

Bokmål mode. In the main task, participants read sentences on a screen while their electrophysiological activity was measured on the scalp. Instructions were presented in the relevant variety for each mode: in Northern Norwegian dialect writing for Northern Norwegian sessions and in Bokmål for Bokmål sessions. Each trial began with a fixation cross lasting 500 ms marking the beginning of a sentence. Words in trial sentences were shown sequentially in the center of the screen using the rapid serial visual presentation (RSVP) technique with a new word every 450 ms without an inter-stimulus interval to facilitate a natural reading rhythm with precise time-locking of the ERPs (Botella & Eriksen, 1992; Dambacher et al., 2012).

Following each trial was a grammaticality judgment task. These offline acceptability measures ensure participants attend to the reading task (the inclusion of such tasks has been associated with greater magnitude brain responses; Molinaro et al., 2011; Osterhout & Mobley, 1995), and they also provide a representation of individual variability in the perception of regionally varying grammatical patterns in dialect versus Bokmål modes. Following each trial, the question *RIKTIG eller GALT?* ("CORRECT or INCORRECT?") appeared on the screen. Participants were instructed to press corresponding response buttons according to their judgment. The buttons were marked *riktig* ("correct") or *galt* ("incorrect") and arranged ipsilaterally to the words on the screen (the left and right buttons, respectively). In the Bokmål mode, participants were instructed to choose RIKTIG if they believed a given sentence conforms to Bokmål orthographic rules, and in the Northern Norwegian mode participants were told to base their responses on whether they believed the sentence to be well formed or not in their dialect. In both sessions, participants were instructed to disregard stylistic elements of the sentence, such as its logical coherence. They were told that there would be a time limit of 3 s to provide their response and asked to try to time eye-blinks following their response between trials.

Each experiment consisted of 180 sentences featuring different forms of long-distance morphosyntactic agreement. The grammaticality of non-/agreement marking in each condition varies and is controlled across participants' spoken dialect and Bokmål, as described in Table 1. These included 60 items with masculine vs. neuter adjectival gender non-/agreement (e.g., *eleven var frekk/frekt* "the student-M. was rude-M./N.") — obligatory in all Norwegian varieties (the control condition); 60 items with dialect-specific adjectival number non-/agreement (e.g., *husene var fine/fin* "the houses-PL. were nice-PL./-∅") — obligatory in Bokmål and Sunnmøre Norwegian but prohibited in Northern Norwegian dialect (the target condition); and 60 filler items with participial number non-/agreement (e.g., *lyktene var tente/tent* "the lanterns-PL. were lit-PL./-∅"), which is generally prohibited in Bokmål and Northern Norwegian dialect but optionally permitted in Sunnmøre Norwegian. Of particular importance for the present study, Sunnmøre Norwegian dialect aligns with Bokmål in terms of both the gender (control) and number (target) conditions, serving as the study's control group. Northern Norwegian participants serve as the target group — matching Bokmål for the control condition (gender agreement) but featuring contrastive grammaticality in the target condition (uniquely prohibiting predicate number agreement on adjectives). For the control and target conditions, we employed the same stimuli set as Kubota et al. (2023), with only minor alterations. The Bokmål version of the experiment used the same stimuli, translated to idiomatic Bokmål. To prevent participants from seeing both versions of the same sentence (with and without agreement), we prepared two experimental lists. Using a Latin square design, we distributed 60 sentences per condition across these sets, resulting in 30 instances of sentences with agreement and 30 instances of sentences without agreement per condition per participant.

The structure of trial sentences is identical across experimental conditions, as shown in the example sentences (2–5). Gender and number agreement was evaluated between the subject of the subordinate clause (following the complementizer *at* "that") and the predicate adjective (following the finite copula *var/va* "was"). Grammatical violations were only modulated on the adjective, and gender and number agreement violations were never combined. In other words, each trial manipulated only gender *or* number agreement at a time, never simultaneously. To control potential wrap-up effects and prevent undue emphasis on the critical word, the critical adjective in each sentence is followed by an additional 2–4 words at the end of each sentence. Finally, though Bokmål and Northern Norwegian are easily mutually intelligible, the dialect modality of each trial sentence is made obvious to participants by significant lexical, morphological, morphosyntactic, and (grapho)phonological differences in each sentence (2–5); for example, these include Northern Norwegian prepropial articles (e.g., NNorw. *ho Liv* vs. Bm. *Liv* "(she) Liv"), distinct pronominal forms (e.g., Bm. *meg/hun* vs. NNorw. *mæ/ho* "me/she"), contrasting nominal allomorphy (Bm. *epl-ene* vs. NNorw. *epl-an* "apples-DEF.(N.)PL."), lexical differences (e.g., Bm. *barn* vs. NNorw. *unga* "children"), among other features.

(2) **Bokmål gender non-/agreement**

*Liv fortalte meg at hund-en hun trente var snill-/*snil-t mot barn*
Liv told me that **dog**-M.DEF.SG. she trained was **kind**-M./*-N. to kids

"Liv told me that the dog she trained was kind to kids."

(3) **Northern Norwegian gender non-/agreement**

*Ho Liv fortalte mæ at hund-en ho trænte va snill-/*snil-t mot unga*
(She) Liv told me that **dog**-M.DEF.SG. she trained was **kind**-M./*-N. to kids

"Liv told me that the dog she trained was kind to kids."

(4) **Bokmål number non-/agreement**

*Tor viste meg at epl-ene han kastet var full-e/*full- av mark*
Tor showed me that **apple**-DEF.PL. he threw were **full**-PL./*∅ of worms

"Tor showed me that the apples he threw out were full of worms."

(5) **Northern Norwegian number non-/agreement**

*Han Tor viste mæ at epl-an han kasta va full-/*full-e av mark*
(He) Tor showed me that **apple**-DEF.PL. he threw were **full**-∅/*-PL. of worms

"Tor showed me that the apples he threw out were full of worms."

In the gender (control) condition, we tested masculine versus neuter agreement marking with balanced numbers of masculine and neuter nouns. While the feminine is currently being lost in many dialects (Busterud et al., 2019; Lohndal & Westergaard, 2021; Rodina & Westergaard, 2021), masculine/neuter contrasts are cross-dialectally stable, unvarying, and overtly marked in both nominal and adjectival morphology. In number conditions, we tested plural versus zero-marked adjectives. All three varieties display singular and plural number agreement on attributive adjectives (e.g., Northern Norwegian *en snill hund* "a kind dog" vs. *snill-e hunda* "kind-PL. dogs"), but predicate plural agreement is uniquely prohibited in Northern Norwegian compared to Bokmål and Sunnmøre Norwegian (Sandøy, 1988); cf., the Bokmål/Northern Norwegian number agreement sentences in (4–5) above. All subject nouns were therefore plural in the number condition since this is the only context where Northern Norwegian differs from the other two varieties under investigation. Number agreement sentences contained equal numbers of plural marked adjectives (grammatical in Bokmål and Sunnmøre Norwegian but ungrammatical in Northern Norwegian) and zero-marked adjectival stems (grammatical in Northern Norwegian but ungrammatical in Bokmål and Sunnmøre Norwegian). ERPs were time-locked to the onset of the critical word (adjective).

Fillers tested sentences with participial number non-/agreement (e.g., *lyktene var tent/e* "the lanterns were lit-∅/PL.") and had a similar structure, including equal numbers of plural and zero-marked participles. However, in contrast to gender and number agreement marking on adjectives, participial number agreement displays considerably greater variation within and across Norwegian dialects. Predicate participial number agreement is generally dispreferred in Bokmål and most Norwegian varieties but optionally permitted in Sunnmøre Norwegian and other Western Norwegian dialects as well as Nynorsk (Dyvik, 2019; Sandøy, 1988). To a varying degree then, all Norwegian speakers have some exposure to predicate participial number agreement, and the filler sentences in this study are therefore on a scale of acceptability, which displays both item, individual, and cross-dialectal variability. These were designed to investigate the neurophysiological correlates of grammatical optionality, but for the sake of space and scope are not analyzed in this paper. A Norwegian language supplement with additional details on Norwegian sociolinguistics and morphosyntax is provided in the supplementary materials on OSF.

Participants

The experiments were conducted with participants over 18 years of age who have Norwegian as their first language. Participants had normal or corrected-to-normal vision, no reading disorders, and no reported history of neurological impairment. Participants were self-identifying as either Northern Norwegian (n = 83, mean age = 37.8, SD = 14.6, Female = 61, Male = 22) or Sunnmøre Norwegian dialect speakers (n = 73, mean age = 42.8, SD = 16.2, Female = 54, Male = 18, Undisclosed = 1). Northern Norwegian participants were born and raised in Nordland, Troms, or Finnmark counties. Because of known geographic variation in participial agreement in Sunnmøre (the filler condition) the selection criteria for Sunnmøre participants was more restrictive, requiring that participants had been raised in one of the central Sunnmøre municipalities: Volda, Ørsta, Vanylven, Herøy, Ulstein, Hareid, Sande, Sykkylven, or Stranda. Most Northern Norwegian participants received their primary education in the Bokmål written standard (n = 76) while most Sunnmøre participants had Nynorsk as their main written language in school (n = 70). However, it is important to note that the gender and number experimental conditions under consideration do not vary grammatically between Bokmål and Nynorsk, and because of the minoritized status of Nynorsk, both Northern Norwegian and Sunnmøre participants — regardless of their main written language — report substantial and regular exposure to Bokmål. For additional detail on the Norwegian sociolinguistic context, see the language supplement on our public OSF site.

Language Social Background Questionnaires and spoken sentence tasks

To assess each participant's engagement with and exposure to Bokmål and their local dialect (in spoken and written domains), we adapted the Language Social Background Questionnaire (LSBQ; Anderson et al., 2018) specifically for Bokmål and each local dialect. The LSBQ was originally designed to map overall levels of bilingual engagement and provides detailed measures of language usage patterns with different speakers in diverse settings. Due to the lack of suitable tools for evaluating engagement/exposure in bilectalism, we modified the LSBQ to assess participants' use of and exposure to their local dialects compared to other dialects. Additionally, we adapted the LSBQ to evaluate participants' use of Bokmål in written domains compared to other written varieties (e.g., Nynorsk, dialect writing). We also employed a third version of the LSBQ to evaluate participants' multilingual experience (primarily Norwegian and English but also considering up to three other foreign languages) which also elicited a wide variety of general sociodemographic and health-related data. This additional broader questionnaire was included alongside Bokmål- and dialect-adapted LSBQs to avoid drawing undue focus to the specific aims of the study. The revised questionnaires are available on our public OSF site.

Anderson et al. (2018) provide a Factor Score Calculator for deriving a continuous composite score from weighted factor scores representing overall bilingual use and exposure in various domains. However, these calculations were designed for and validated using diverse bilingual communities in which English is the official language. Given the distinct nature of bilectal use and exposure in Norway, the underlying factors and their weightings relevant in bilingual environments may not directly apply to bilectal contexts. We elected therefore to conduct separate exploratory factor analyses (EFAs) for the dialect and Bokmål questionnaires to extract latent factors predicting bilectal Bokmål and dialect engagement and exposure.

For the Bokmål questionnaire, we first removed 15 items which were highly correlated (> .7) or which had low Kaiser–Meyer–Olkin (KMO) values (< .65). We then assessed the suitability of the data for factor analysis. The KMO measure of sampling adequacy was 0.89, indicating good suitability. Bartlett's test of sphericity was significant ($\chi^2 = 1110.29$, $p < 0.001$), supporting the factorability of the correlation matrix. Cronbach's alpha for the remaining items was 0.902, indicating excellent internal consistency. We then conducted the EFA using maximum likelihood extraction with ProMax rotation, allowing factors to be correlated. Kaiser's criterion suggested retaining two factors (Kaiser, 1960), while the scree plot indicated two to three factors. We opted for a two-factor solution, which explained 48% of the total variance. Factor 1 (social use) included items such as emailing, texting, and social activities, with loadings ranging from 0.39 to 0.94. Factor 2 (contextual use) included items such as reading, writing, and school activities, with loadings from 0.56 to 0.81. These factors were moderately correlated ($r = -0.64$). Individual factor scores were obtained for each participant, and composite scores were calculated from the sum of social and contextual use factors to better evaluate individual differences in Bokmål engagement and exposure.

For the dialect questionnaire, we similarly removed 13 items which were highly correlated (> .7) or which had low KMO values (< .65) and then assessed data suitability. The KMO measure was 0.81, also indicating good suitability, and Bartlett's test was significant ($\chi^2 = 1096.75$, $p < 0.001$). Cronbach's alpha for the remaining items was 0.827, indicating good internal consistency. The EFA, using the same extraction and rotation methods, suggested retaining three factors, which explained 52% of the total variance. Factor 1 (literary use) included items related to reading, texting, and social media, with loadings from 0.52 to 0.85. Factor 2 (social exposure) included items such as social activities and interactions with friends and neighbors, with loadings from 0.35 to 1.05. Factor 3 (public exposure) included items such as work and official places, with loadings from 0.54 to 1.00.

The factor correlations ranged from −0.042 to −0.67. Individual factor scores were extracted, and composite scores were calculated from the sum of the three factors to measure comprehensive dialect engagement and exposure.

Both Bokmål and dialect composite scores are used in further analyses of the study's ERP and behavioral results to approximate how the totality of individuals' Bokmål and dialect use and exposure influence individual differences in language processing and behavioral outcomes. More detailed information on the EFAs can be found in the study's analysis script on our OSF site.

In addition to the questionnaires, a spoken sentence reading task was administered at the end of the experimental session to provide a rough measure of participants' spoken dialect and any potential variability in agreement marking with respect to the study's target condition. In this task, participants were audio recorded while reading a series of sentences in their spoken dialect. The sentences were presented in Bokmål but were designed to elicit local dialect features (e.g., plural number marking and other dialect-specific morphophonological and morphosyntactic features). As expected, Northern Norwegian participants consistently display plural number zero-marking.

Procedure

Upon arrival, participants reviewed and signed an informed consent form. The experiments reported in this article were approved by the Norwegian Centre for Research Data (NSD). Participation was voluntary, and participants were informed that their data would be anonymized and that they could withdraw their consent at any point without any adverse consequences. Participants completed a series of questionnaires during the cap preparation and system setup, which took on average 30–40 minutes. As outlined further above, these questionnaires elicited general sociodemographic and health-related data as well as mapped their linguistic experience and proficiency in speaking, listening, reading, and writing in Norwegian, English, and up to three other foreign languages. A subset of questions focused on their level of engagement with and exposure to Bokmål and their native-spoken dialect. Following completion of these questionnaires, cap preparation, and system setup, the online reading experiment started. The 180 sentences were divided into six blocks of 30 sentences. Participants were encouraged to rest at every break and continue at their own pace. The order of trial sentences was pseudo-randomized such that each block contained five sentences from each condition (20 from the four experimental conditions and 10 from the fillers). Two sentences from the same condition could be, at the closest, five items apart. Following the ERP experiment, participants took part in the spoken sentence reading task, reading 5–8 sentences eliciting local morphophonological/morphosyntactic features.

Data acquisition and pre-processing

During the on-line reading experiment, continuous EEG was recorded from 32 active electrodes (ActiCap, Brain Products, Inc.) fitted in an elastic cap, organized according to the international 10–20 system. Before recording, impedances were lowered to below 20 kΩs for all electrodes. The frontal electrodes FP1 or FP2, located on the forehead, and temporal electrodes FT9 and FT10, located near the temples, were used to monitor participants' vertical and horizontal electro-ocular activity, respectively. The recordings were amplified by a LiveAmp amplifier (Brain Products, Inc.) and digitized continuously at a sampling rate of 500 Hz. AFz served as the ground electrode, and the EEG recording was referenced online to electrode FCz.

After acquisition, pre-processing of the EEG data was conducted using Brain Vision Analyzer 2.2 software (Brain Products, Inc.). First, the continuous raw EEG data were manually inspected, and any bad channels were interpolated from neighboring good channels. The EEG data were then band-pass filtered using a zero-phase shift Butterworth filter, with low and high half-amplitude cutoffs of 0.1–30 Hz, each with a 24 dB/octave roll-off. Finally, a notch filter was applied at 50 Hz to reduce line noise. The continuous EEG was then segmented into 4800 ms epochs, approximately the full length of a trial sentence. This was done to ensure maximal clean trial data for component evaluation and rejection. Individual components mainly accounting for ocular movement, cardiac signals, or channel-specific noise were removed using Brain Vision Analyzer's semi-automatic Ocular Correction Independent Component Analysis (ICA) procedure. Manual component rejection was guided by components' topography, time series, and properties of the dipole associated with each component. 1–3 components were removed for each participant on average. After component rejection, the data were re-segmented into epochs from −300 to 1200 ms around the critical words and baseline corrected to the mean voltage of a 100 ms pre-stimulus period. Prior to artifact rejection, the baseline corrected segmented data were manually inspected with ±75 μV amplitude differences as well as 100 μV of max–min differences within ±200 ms intervals as artifact criteria within individual channels. We further excluded trials in which eye-blinks were detected immediately prior to or during the stimulus presentation (−200–500 ms) to ensure that subjects saw the critical word unobstructed. Overall, the mean rate of rejected trials was 14.2%. All remaining trials, regardless of performance in grammatical acceptability judgment tasks, were considered for analysis. As a final step, the data were re-referenced to the average linked mastoids (TP9/10).

Results: Experiments 1–2 — Cross-dialectal Bokmål on-line reading

For the sake of clarity and ease of explication, the results from the three experiments are presented in pairwise comparisons, contrasting experiments 1–2 and experiments 2–3, respectively. The first set of experiments test on-line reading in one variety (Bokmål) with two dialect groups — Sunnmøre and Northern Norway — testing grammatical conditions with varying contrastivity between participants' spoken dialect and Bokmål. By comparison, experiments 2–3 were run in one dialect region — Northern Norway — testing individuals' Bokmål vs. Northern Norwegian dialect grammatical processing in separate sessions, using the same mis/matched grammatical conditions as Experiment 1.

ERP results

Grand average ERP waveforms for the Bokmål reading task, time-locked to the onset of the non-/agreeing adjective, are presented in Fig. 2. The waveforms are recorded at centro-parietal and neighboring central, parietal, and occipital electrode sites (C3, Cz, C4, CP5, CP1, CP2, CP6, P7, P3, Pz, P4, P8, O1, Oz, O2) where P600 effects are typically largest; see Tanner and Hell (2014) and Tanner et al. (2015) for similar approaches. Topographic maps depict the distribution of the P600 effect for each dialect mode and each condition, computed from non-agreement minus agreement trial differences for a narrow P600 time window (600–900 ms). To ensure data quality, participants with low quality recordings — those with a high rate of artifacts and/or eye-blinks — have been removed (greater than 20% rejected trials; mean good trials = 52.5%, SD = 21.7%). Participants with well below chance accuracy (<35%) on grammaticality judgment tasks for the gender control condition have also been removed from further analysis (i.e., participants who are not actively participating or who may have misunderstood the order of correct and incorrect response buttons). This led to the removal of 3 participants. The remaining 119 participants (Sunnmøre, n = 59; Northern Norway, n = 60) have on average 93.9% good trials (SD = 5.6%).

Group-level effects of morphosyntactic non-/agreement on ERPs were evaluated using a cluster-based permutation analysis (CPA) using the *clusterperm.lmer* function from the permutes package in R (Voeten, 2022). This approach infers the null distribution from permuted data

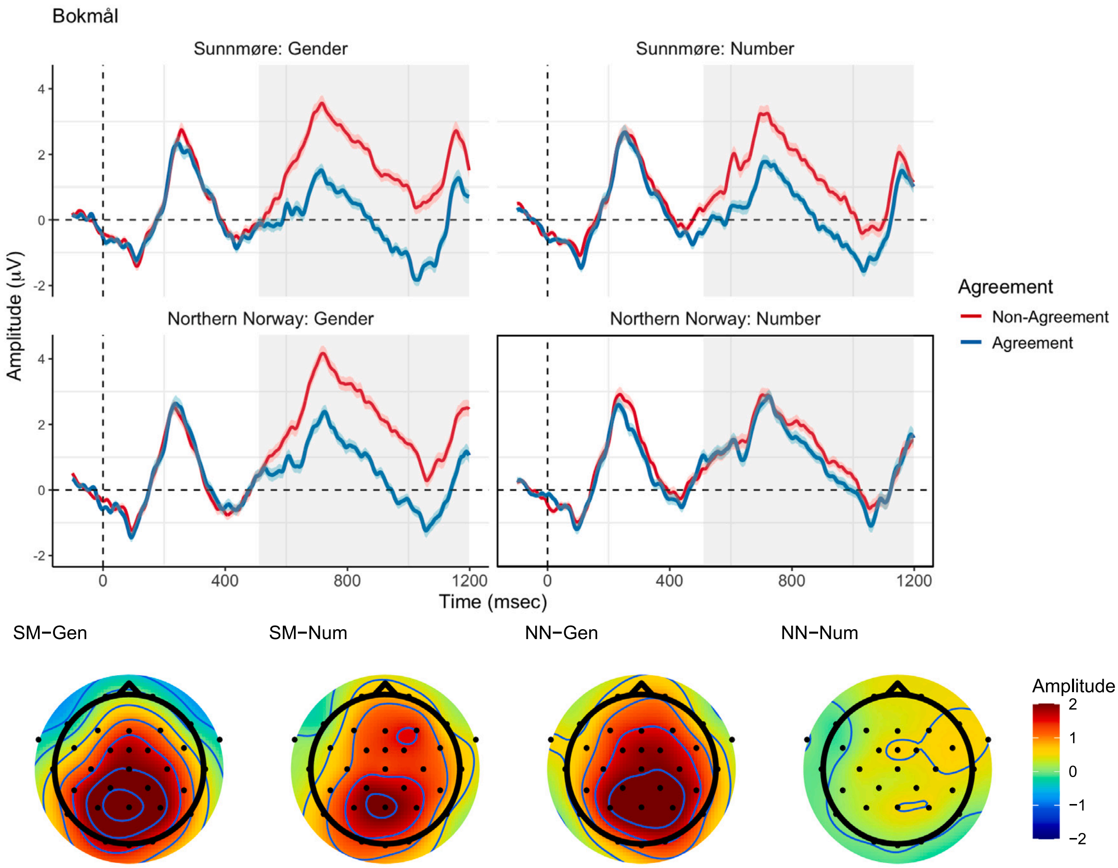

Fig. 2. ERP waveforms recorded at central, parietal, and occipital electrodes for gender and number agreement among Northern Norwegian and Sunnmøre Norwegian participants while they read sentences with agreement (blue) and without agreement (red) in Bokmål. The topography of the effect of agreement (non-agreement minus agreement) within the P600 time window is plotted below the waveforms (SM = Sunnmøre; NN = Northern Norway). The target condition in the target group (Northern Norway:Number) is highlighted, which reveals significant attenuation of ERP amplitudes where Bokmål and Northern Norwegian participants' dialect are grammatically incongruent. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

with linear mixed effects models, using permuted Likelihood Ratio Tests to compute a cluster-mass statistic (Lee & Braun, 2012; Maris & Oostenveld, 2007; Sassenhagen & Draschkow, 2019). Due to the computational demands of permutation testing on large ERP datasets, the CPA was conducted with by-subject condition-averaged data. To assess the main effect of agreement and its interactions, we ran an initial CPA testing a model with a three-way interaction of *Agreement* (agreement, non-agreement), *Condition* (gender, number), and *Group* (Sunnmøre, Northern Norway), including by-electrode and by-subject random intercepts. To account for potential individual differences in sensitivity to the specific type of agreement violation, we also included by-subject random slopes for *Condition*. Factors were coded using treatment contrasts. The number of permutations was set to 2000. This analysis revealed a significant effect of agreement (cluster mass = 573180.3, $p < .001$), corresponding to a cluster within the typical broad P600 window (approximately 510–1200 ms), represented in Fig. 2 via shading.

To further quantify these effects, we ran a linear mixed effects model (LMM) on trial-level ERP amplitudes within a subset of roughly the same time window (550–1150 ms), including the same three-way interaction between *Agreement*, *Condition*, and *Group* and incorporating by-item, by-electrode, and by-subject random intercepts with by-subject random slopes for *Condition* to account for potential individual variability in sensitivity to gender vs. number agreement violations. All factors were coded using treatment contrasts. The *sjPlot* package was employed to produce diagnostic visualizations, ensuring that model assumptions were met (Lüdecke, 2023). Diagnostic plots revealed heavy tails in the residuals, suggesting the presence of outliers. To address this issue, we identified and excluded data points with standardized residuals exceeding ±2 SDs, which accounted for 4.73% of the total data. The final model, excluding these outliers, was then re-evaluated to ensure better adherence to model assumptions. Using the *emmeans* package (Lenth et al., 2023), estimated marginal means (emmeans) were calculated for interactions between factors, with *p*-values adjusted using Tukey's HSD method to control for multiple comparisons. The results are reported as mean differences to represent amplitude differences between agreement and non-agreement trials (Table 2).[2] Throughout the manuscript, we will consider an alpha of .05 as the threshold for statistical significance. Full model summaries and additional statistics are provided in the analysis script on OSF.

[2] Note that effect sizes in ERP studies are generally commonly calculated using participant- and condition-level averaged data (see, e.g., Larson & Carbine, 2017, and Meyer et al., 2021), but averaging significantly reduces variance in the data, leading to reduced standard error estimates, inflated *t*-values, and smaller *p*-values. Because of the small signal-to-noise ratio in EEG data, averaging can significantly inflate effect size estimates. In the way of an illustration, when calculated using by-electrode and by-participant averaged data, the model estimates in Table 2 are nearly identical, but the Cohen's *d* values are approximately 4–5 times larger, ranging from 0.306 (Northern Norway:Number) to 1.279 (Sunnmøre:Gender). In this paper, effects are analyzed using item-level data to provide more accurate estimates that account for the full variability in the data.

Table 2
Estimated marginal means (emmeans) with 95% confidence intervals (CI), significance, and effect sizes across groups for gender and number conditions. The dialect–Bokmål grammatically incongruent condition (Northern Norway: Number) is highlighted.

Group	Condition	Contrast	EMMeans	95% CI		*p*-value	Cohen's *d*
				Lower	Upper		
Sunnmøre	Gender	Non-Agr. − Agr.	1.72	1.36	2.08	< .001	0.294
Northern Norway	Gender	Non-Agr. − Agr.	1.57	1.21	1.93	< .001	0.268
Sunnmøre	Number	Non-Agr. − Agr.	1.30	0.94	1.66	< .001	0.223
Northern Norway	Number	Non-Agr. − Agr.	0.41	0.05	0.76	.027	0.069

Group-level results

The gender condition distinguishes masculine–neuter agreement on predicate adjectives (e.g., *the dog*-M. *is kind*-M./*N.), which is grammatical and obligatory in all Norwegian varieties (the control condition). The number condition by contrast manipulates predicate adjective plural agreement (e.g., *the dogs*-PL. *are kind*-PL./∅). This condition features cross-dialectal variation: plural agreement is grammatical in Sunnmøre Norwegian and Bokmål but ungrammatical in Northern Norwegian, and by contrast zero-marking (non-agreement) is grammatical in Northern Norwegian but ungrammatical in Sunnmøre Norwegian and Bokmål. In the three grammatically congruent (control) conditions, where both Sunnmøre and Northern Norwegian participants' dialects are grammatically aligned with Bokmål, both groups display similar, robust effects of Agreement, corresponding to large, broadly distributed positive deflections around 500–1200 ms. This is the P600 component, indexing the detection of a morphosyntactic violation (the lack of gender or number agreement). For the control condition, post-hoc comparisons reveal the differences in amplitude between gender agreement and non-agreement trials are comparable between the groups (Sunnmøre — emmeans, difference: 1.72 μV ± 0.184 SE, $p < .001$, Cohen's $d = 0.294$; Northern Norway — emmeans, difference: 1.57 μV ± 0.183 SE, $p < .001$, Cohen's $d = 0.268$).

For the target condition, the difference in amplitude between number non-agreement and agreement trials for Sunnmøre participants is comparable to the gender condition (emmeans, difference: 1.30 μV ± 0.184 SE, $p < .001$, Cohen's $d = 0.223$). By contrast, for Northern Norwegians, whose spoken dialect and Bokmål have reversed grammaticality for plural number agreement marking, ERP responses are overall significantly reduced (Fig. 2: Northern Norway:Number), and though the effect of agreement on amplitude differences is significant (emmeans, difference: 0.41 μV ± 0.185 SE, $p = .027$), the effect is overall negligible at the group level (Cohen's $d = 0.069$), highlighting the interaction between participants' contrasting spoken dialect and Bokmål grammars. In other words, the attenuation of ERPs in this condition suggests significant influence of bilectal grammatical contrastivity on morphosyntactic processing.

Individual ERP differences

The group differences in number agreement P600s in Fig. 2 suggest that participants' processing of Bokmål grammatical patterns are influenced by grammatical in/congruency with their spoken dialect. To further explore how these results vary at the individual level in relationship to individual linguistic factors, we ran another LMM investigating the effects of individual bilectal engagement/exposure on P600 amplitudes. To avoid bias in the time window selection, we built two LMMs — one for a pre-determined, *a priori* P600 time window of 500–900 ms (cf., Allen et al., 2003; Kubota et al., 2023; Regel et al., 2014) and one for the broad time window (550–1150 ms), roughly corresponding to the time cluster identified by the CPA above. The models do not meaningfully differ. Here we present the narrower time window results, replicating the analysis of Kubota et al. (2023).

This model includes item-level *Amplitude* averages within the 500–900 ms time window as the dependent variable. Fixed effects included a four-way interaction, encompassing *Condition* (gender, number), *Agreement* (agreement, non-agreement), *Group* (Northern Norway, Sunnmøre), and *Bokmål engagement/exposure* composite factor scores. Since these studies were conducted with a diverse aging population (ages 18–80), a second three-way interaction including *Age*, *Agreement*, and *Group* was included to control for effects of aging on ERP non-/agreement amplitudes (i.e., age-related reduced working memory capacity and slower processing speed; see Caplan et al., 2011; Dorme et al., 2023; Xu et al., 2017). Age as well as Bokmål experiential factor scores were scaled using z-scoring to facilitate model convergence and interpretation. The random structure of this model contained random intercepts for *Item*, *Subject*, and *Electrode* as well as by-subject random slopes for *Condition* to account for potential individual differences in sensitivity to agreement violations between conditions. All factors were coded using treatment contrasts. To unpack the complex interactions in our model, such as how Bokmål engagement/exposure might shape ERPs under specific conditions of interest, estimated trends (emtrends) were calculated to determine the slopes of Bokmål engagement/exposure for each group and condition. Amplitude prediction values for the four-way interaction between *Group*, *Condition*, *Agreement*, and *Bokmål engagement/exposure* are presented in Fig. 3, and emtrends are presented in Table 3.

The three-way interactions between *Agreement*, *Condition*, and *Group* (1.27 ± 0.163 SE, $p < .001$) and *Agreement*, *Group*, and *Age* (−0.349 ± −0.053 SE, $p < .001$) were significant. The interaction between *Agreement*, *Condition*, and *Bokmål engagement/exposure* was marginally significant (−0.235 ± 0.121 SE, $p = .052$), but the influence of *Bokmål engagement/exposure* in the higher-order four-way interaction appears not significant (−0.128 ± 0.156 SE, $p = .410$). It is important to note however that this is not unexpected and due in part to the nested structure of our design, which includes a high number of Bokmål–dialect grammatically aligned (control) conditions (i.e., dialect–Bokmål structurally overlapping Sunnmøre:Gender, Sunnmøre:Number, Northern Norway:Gender sub-conditions). These conditions — where Bokmål and participants' dialects are morphosyntactically congruent — mask the more subtle effects of Bokmål experience in this model since we *a priori* do not expect bilectal engagement/exposure to matter *except* in the sub-group of cases where participants' dialect and Bokmål grammars are contrastive (i.e., only for the rightmost Northern Norway:Number sub-condition in Fig. 3). To test the more specific effect of Bokmål use and exposure where we expect it to matter (where participants' dialect and Bokmål are grammatically incongruent), emtrends were calculated for factor–covariate interactions which estimates the slopes of Bokmål engagement/exposure trends for each group and condition (Table 3; see Kubota et al., 2023, for a similar approach).

As anticipated, Sunnmøre participants showed no significant modulation by Bokmål engagement/exposure in either gender or number conditions (Table 3). Similarly, Northern Norwegian participants also show no significant effect of Bokmål experience in the gender condition (emtrends: −0.049, 95% CI[−0.186, 0.088], $p = .482$). The absence of influence of Bokmål experience in these control conditions provide a good validity assessment of the study's measures. By comparison, where participants' dialect and Bokmål are grammatically contrastive (the highlighted Northern Norway:Number condition), Bokmål experience predicts clear trends in agreement processing, revealing increasing amplitude differences with increasing Bokmål engagement and exposure (emtrends: 0.314, 95% CI[0.178, 0.451], $p < .001$).

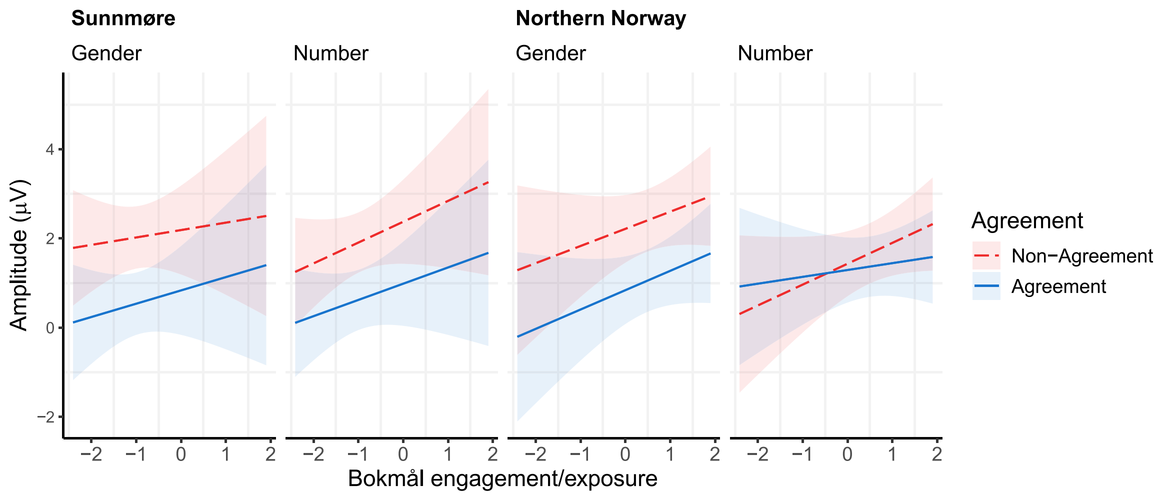

Fig. 3. Predicted Bokmål P600 amplitude values for gender and number agreement between Sunnmøre and Northern Norway groups at difference levels of Bokmål engagement/exposure (z-scored).

Table 3
Estimated slopes with 95% confidence intervals (CI), significance, and effect sizes across groups for gender and number conditions. The last row (Northern Norway: Number) representing the dialect/Bokmål grammatically contrastive target condition is highlighted.

Group	Condition	Contrast	Slope	95% CI Lower	95% CI Upper	p-value	Cohen's d
Sunnmøre	Gender	Non-Agr − Agr	−0.132	−0.302	0.038	.128	−0.023
Sunnmøre	Number	Non-Agr − Agr	0.103	−0.066	0.272	.233	0.018
Northern Norway	Gender	Non-Agr − Agr	−0.049	−0.186	0.088	.482	−0.008
Northern Norway	Number	Non-Agr − Agr	0.314	0.178	0.451	< .001	0.054

These findings demonstrate that where participants' spoken dialect and Bokmål are grammatically contrastive (Northern Norway:Number), greater exposure to and use of Bokmål correlates with increased (non-agreement) P600 amplitudes (Fig. 3, rightmost panel). And vice versa, participants with particularly low Bokmål engagement/exposure exhibit significantly reduced, and even reversed, ERP magnitude differences. This correlation suggests that decreasing Bokmål use and exposure leads to increased influence of the language users' dialect grammar during Bokmål reading, significantly modulating ERP responses to number agreement. Together these findings underscore the complex interplay between cross-dialectal grammatical similarity and individual linguistic experience in shaping neural responses to dialect-specific grammatical patterns.

Behavioral results

In this study, we additionally collected acceptability judgments following each trial. The aggregate results of these grammaticality judgment tasks are presented in Fig. 4, which provides density plots, representing the rate of grammatical acceptance for each condition by each group in the Bokmål mode. As before, participants with well below chance acceptance (< 35%) on gender control conditions have been removed from further analysis. The final participant numbers for the behavioral analysis are: Northern Norway ($n = 80$) and Sunnmøre (n = 72). To ensure individual response consistency throughout the experiment, we compared individual acceptance rates between the first and second halves of the experiment and found no significant changes in behavior (e.g., due to fatigue effects).

The experimental effects are qualitatively overall similar to the previously reported ERP findings. As shown in Fig. 4, both groups display similar, accurate discrimination of un/grammatical non-/agreement trials for the gender control condition. In the number condition, both groups accept plural agreement at equally high rates. This is notable since predicate plural agreement is ungrammatical in Northern Norwegian dialects. But when it comes to *rejecting* sentences that are ungrammatical in Bokmål but grammatical in Northern Norwegian dialects (Fig. 4, Number: Non-Agreement), we observe substantial group differences. Northern Norwegian participants tend to accept number non-agreement (grammatical in their dialect) at well above chance level (mean = 0.615, SD = 0.487) and at roughly twice the rate of Sunnmøre Norwegians (mean = 0.317, SD = 0.465).

To assess these effects in detail, we fitted a mixed-effects logistic regression model with *Acceptance* as the response variable, using a binomial family with a logit link function. The model otherwise incorporated the same structure as the corresponding LMM outlined in the ERP results section, including the fixed effects *Agreement*, *Condition*, *Group*, and their interaction. A second three-way interaction between *Agreement*, *Group*, and *Age* (z-scored) is included to analogously control for potential age-related differences in sensitivity to agreement violations. *Subject* and *Item* were included as random intercepts as well as by-subject random slopes for *Condition*. This model revealed a significant interaction between *Agreement*, *Condition*, and *Group* (0.770 ± 0.205 SE, $p < .001$) as well as *Agreement*, *Group*, and *Age* (-0.292 ± 0.104 SE, $p = .005$). Estimated marginal means reveal the difference between the groups in the number non-agreement subcondition is significant (emmeans, difference: -1.485 ± 0.20 SE, $p < .001$).

Individual behavioral differences

The asymmetries in number non-agreement judgments in Fig. 4 mirror the group-level ERP patterns outlined in the ERP results section above. To investigate corresponding individual differences in the perception of Bokmål grammaticality, we ran a generalized linear mixed effects model with *Acceptance* (accept, reject) as the dependent variable. The model used a binomial family with a logit link function and included the same fixed effects and same interactions as the corresponding LMM outlined in the ERP analysis. *Subject* and *Item* were

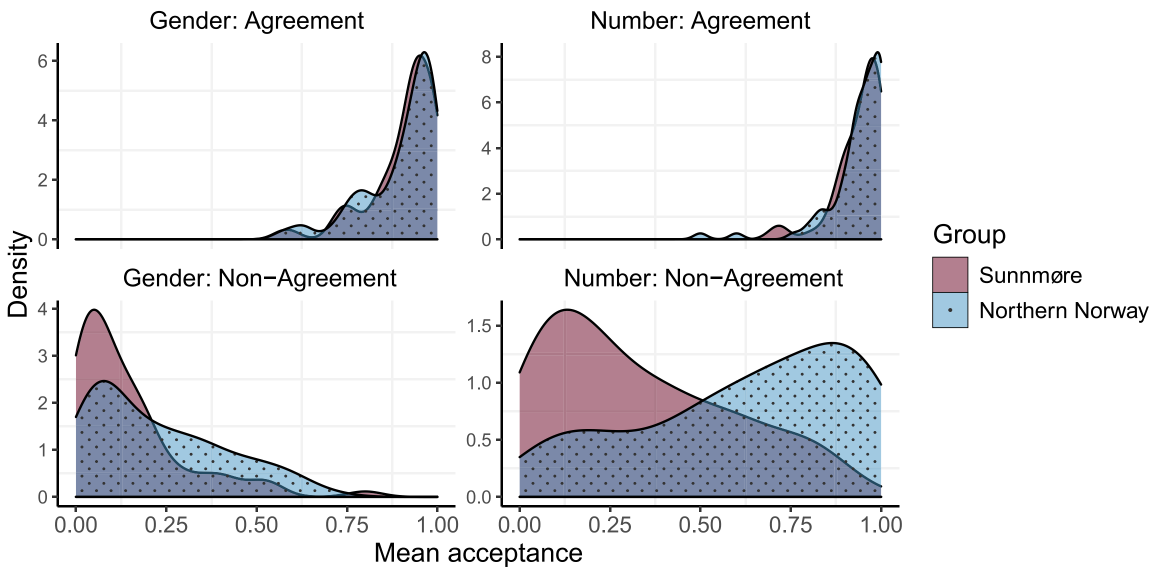

Fig. 4. Mean acceptance density plots for gender and number non-/agreement in Bokmål by Sunnmøre and Northern Norwegian dialect speakers.

included as random intercepts as well as by-subject random slopes for *Condition*. Age as well as Bokmål experiential factor scores were scaled using *z*-scoring. Factors were coded using treatment contrasts. Alike the ERP analysis above, we use emmeans to clarify relevant interactions in the model.

Acceptance prediction values for the four-way interaction between *Group*, *Condition*, *Agreement*, and *Bokmål engagement/exposure* are presented in Fig. 5. Focusing on relevant interactions in this model, there were significant interactions between *Bokmål engagement/exposure*, *Agreement*, and *Group* (−0.417 ± 0.207 SE, $p = .044$) and a marginally significant effect of *Age*, *Agreement*, and *Group* (−0.203 ± 0.106 SE, $p = .055$). Similar to the ERP results above, the influence of *Bokmål engagement/exposure* in the higher-order four-way interaction is not significant (−0.273 ± 0.297 SE, $p = .358$), but as discussed further the ERP results above, this is to be expected given the nested structure of our design where Bokmål engagement/exposure is *a priori* not expected to influence results *except* in the sub-case of conditions where participants' dialect and Bokmål grammars are misaligned (i.e., as demonstrated by the group-level differences in the Number: Non-Agreement subcondition in Fig. 4 and corresponding individual agreement acceptance differences in the Northern Norway:Number panel of Fig. 5).

The estimated marginal trends in Table 4 reveal that the Sunnmøre group shows no influence of Bokmål engagement/exposure on either gender or number non-/agreement grammaticality judgments. By contrast, Northern Norwegian participants with increased Bokmål engagement/exposure show increased accuracy on gender non-/agreement grammaticality judgment tasks (emtrends: 0.498, 95% CI[0.278, 0.718], $p < .001$), suggesting that this effect might be a more general effect of overall heightened grammatical awareness with increased Bokmål experience. However in the number condition, in contrast to Sunnmøre Norweigans, Northern Norwegian subjects show overall significantly less accurate acceptability judgments (Figs. 4–5) as well as notable influence of Bokmål engagement/exposure on acceptability judgment rates (emtrends: 0.494, 95% CI[0.248, 0.740], $p < .001$). These results are visualized in the rightmost panel of Fig. 5. Northern Norwegian participants show increasingly accurate responses with increasing Bokmål engagement/exposure, and at the low end of this spectrum, nearly do not distinguish the grammaticality of non-/agreement trials.

These behavioral results suggest that grammatical dissimilarity between one's spoken dialect and Bokmål can significantly influence grammaticality judgments, leading to less accurate and more gradient acceptance of number non-/agreement trials among Northern Norwegian participants compared to Sunnmøre Norwegian controls. However, mirroring the modulation of ERP amplitude differences observed above, these results further illustrate that bilectal linguistic experience matters; at the individual level, these effects of cross-linguistic influence on acceptability judgments are negated with higher Bokmål engagement/exposure levels and, vice versa, increased with decreasing Bokmål experience.

Interim discussion

Taken together, these results from Experiments 1–2 indicate a clear pattern: grammatical congruence between one's spoken dialect and Bokmål significantly influences Bokmål processing. This cross-linguistic influence (CLI) is evident in both on-line (ERP) and off-line (behavioral) measures. Specifically, participants from Northern Norway, whose spoken dialect differs grammatically from Bokmål with respect to predicate number agreement marking, exhibit attenuated ERP responses (Fig. 2) and less accurate grammaticality judgments (Fig. 4) compared to participants from Sunnmøre, whose dialect is structurally aligned with Bokmål.

The impact of CLI is not uniform but varies significantly among individuals, primarily influenced by their level of engagement with and exposure to Bokmål. When parsing bilectally contrastive plural number agreement, Northern Norwegians with greater Bokmål use and exposure show larger amplitude responses (Fig. 3) and more accurate rejection of ungrammatical sentences (Fig. 5). Conversely, those with low Bokmål engagement display ERP and behavioral patterns more influenced by their native Northern Norwegian dialect, indicating minimal discrimination between grammatical and ungrammatical sentences.

In summary, these findings highlight the complex interplay between grammatical and individual linguistic experience in shaping neural and behavioral responses to narrow linguistic variation in diglossic contexts which involve closely related varieties. These findings suggesting that bilectals develop distinct grammatical representations for subtle differences between L1 varieties, with their brain and behavioral responses modulated by the extent of their engagement/exposure to each variety. This results in a gradient of competition between the grammatical rules of Bokmål and Northern Norwegian at the individual level, which we observe as a spectrum in greater and lesser ERP responses and more and less discriminate acceptability judgments.

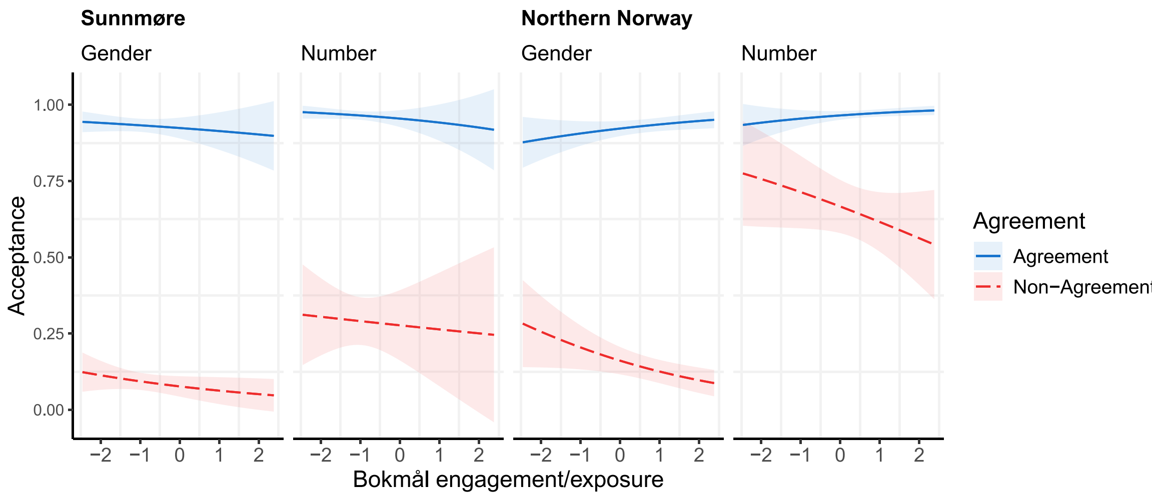

Fig. 5. Predicted Bokmål grammaticality acceptance levels for gender and number agreement between Sunnmøre and Northern Norway groups at differing levels of Bokmål engagement/exposure (z-scored).

Table 4
Estimated slopes with 95% confidence intervals (CI), significance, and effect sizes across groups for gender and number conditions. The last row (Northern Norway: Number) representing the dialect/Bokmål grammatically contrastive target condition is highlighted.

Group	Condition	Contrast	Slope	95% CI		*p*-value	Cohen's *d*
				Lower	Upper		
Sunnmøre	Gender	Agr − Non-Agr	0.081	−0.259	0.421	.642	0.081
Sunnmøre	Number	Agr − Non-Agr	−0.197	−0.559	0.165	.287	−0.197
Northern Norway	Gender	Agr − Non-Agr	0.498	0.278	0.718	< .001	0.498
Northern Norway	Number	Agr − Non-Agr	0.494	0.248	0.740	< .001	0.494

Results: Experiments 2–3 — Bilectal grammatical processing

Building on the findings described above, a subsequent experiment was conducted to examine on-line reading processing in Northern Norwegian dialect; for more background on the use of dialect writing in Northern Norway, see our Norwegian language supplement on OSF. This study followed up with 66 of the original participants from experiment 2, all from Northern Norway, and uses the same grammatically in/congruent conditions as experiments 1–2, with the same stimuli translated from Bokmål to Northern Norwegian dialect writing. As with the Bokmål experiments, to avoid participants from seeing both versions of the same sentence (with and without agreement), two experimental lists were used. Using a Latin square design, 60 sentences per condition were distributed across these sets, resulting in 30 instances of sentences with agreement and 30 instances of sentences without agreement per condition per participant. Between experiments 2–3, each participant is tested in two separate sessions with at least a week in between sessions. Collectively, experiments 2 and 3 are framed to explore individual bilectal grammatical processing in two distinct Norwegian varieties — Bokmål and Northern Norwegian dialect — testing to what extent individuals display distinct processing patterns for contrastive, dialect-specific grammatical patterns.

ERP results

Fig. 6 presents the grand average waveforms for Northern Norwegian participants during both Bokmål and Northern Norwegian reading tasks. As with experiments 1–2, participants with excessive artifacts (greater than 20% rejected trials; mean good trials = 51.9%, SD = 23.7%) were excluded to ensure data quality. Two participants were further removed due to low (< 35%) accuracy on gender control grammaticality judgment tasks. The remaining participants (Bokmål, n = 60; Northern Norway, n = 52) have a high average 94.1% of usable trials (SD = 5.1%).

Mirroring the analyses of the Bokmål data from experiments 1–2, we evaluated group-level effects of morphosyntactic non-/agreement on ERPs using a cluster-based permutation analysis with LMMs. To test the effect of grammatical non-/agreement on ERP amplitudes across conditions between the two dialect modes, we ran an analysis including a three-way interaction between *Agreement*, *Condition*, and *Dialect* with by-electrode and by-subject random intercepts. Factors were coded using treatment contrasts. By-subject random slopes for *Condition* were included to account for potential individual variability in sensitivity to gender vs. number agreement violations. The number of permutations was set to 2000. This analysis revealed a significant main effect of *Agreement* (cluster mass = 459333.80, $p < .001$) within the typical P600 window, between roughly 510–1200 ms, represented in Fig. 6 via shading.

Similar to our analysis of experiments 1–2, we further employed an LMM to evaluate the ERP data for experiments 2–3, focusing on the effects of the dialect mode on morphosyntactic processing using item-level mean amplitudes within roughly the time cluster identified above (550–1150 ms). For this analysis, ERP amplitudes were modeled using the same fixed and random effects structure as the CPA above, including random intercepts for *Item*, *Electrode*, and *Subject* as well as by-subject random slopes for *Condition*. Outliers were identified and excluded based on standardized residuals exceeding ±2 SDs, accounting for 4.79% of the data. Subsequently, model diagnostics were performed using the *sjPlot* package, ensuring the final model adhered to assumptions of normality and homoscedasticity. Estimated marginal means (emmeans) were calculated for interactions between factors using the *emmeans* package (Lenth et al., 2023), with *p*-values adjusting using Tukey's HSD method to control for multiple comparisons (Table 5).

Group-level results

Experiments 2–3 incorporate the same grammatical conditions as outlined in the materials and design section, only that the grammaticality for the number condition is reversed between the two sessions. Specifically, predicate plural number *agreement* is grammatical

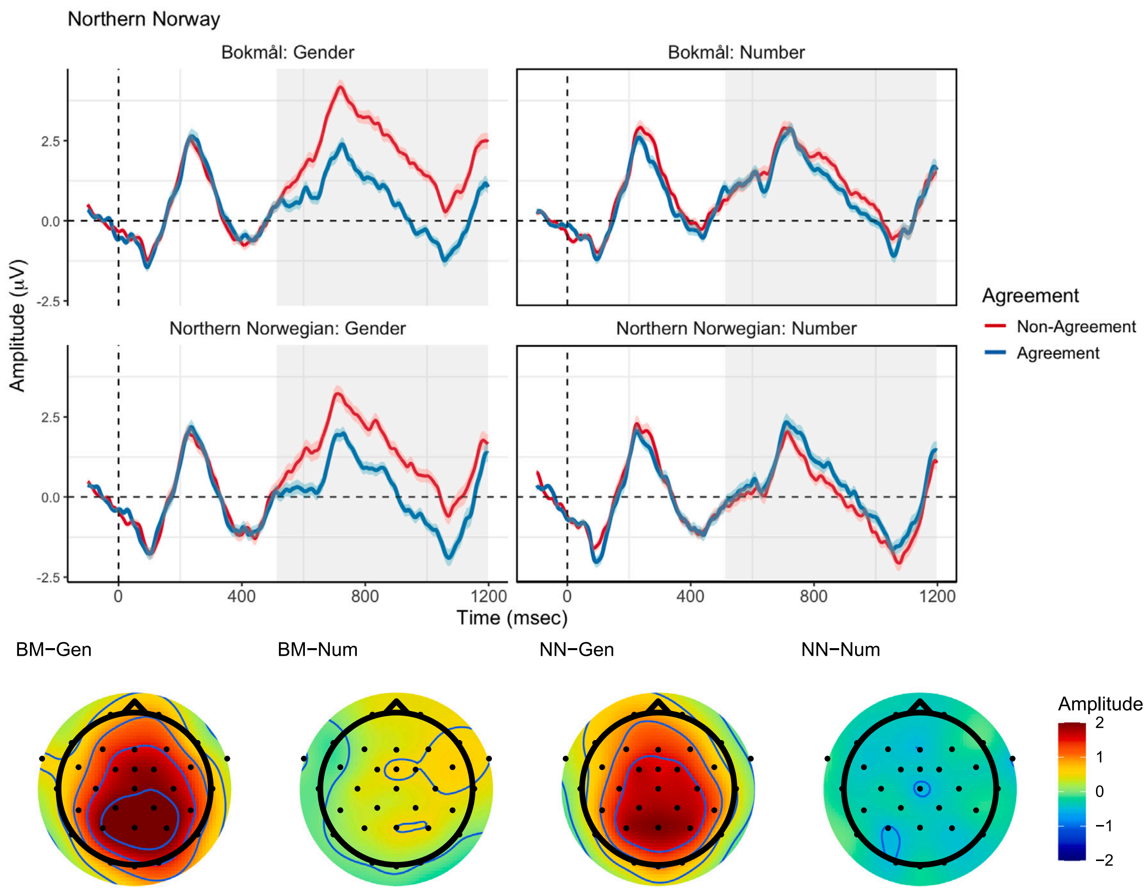

Fig. 6. ERP waveforms recorded at central, parietal, and occipital electrodes for gender and number agreement among Northern Norwegian participants while they read sentences with agreement (blue) and without agreement (red) in Bokmål vs. Northern Norwegian dialect writing. The topography of the effect of agreement (non-agreement minus agreement) within the P600 time window is plotted below the waveforms (BM = Bokmål; NN = Northern Norwegian). Cross-dialectally varying number conditions are highlighted, illustrating the replicated attenuation of ERP amplitudes in both dialect modes where participants' native-spoken dialect and Bokmål are grammatically incongruent. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 5
Estimated marginal means (emmeans) with 95% confidence intervals (CI), significance, and effect sizes between dialect modes for gender and number conditions. Dialect–Bokmål grammatically incongruent number conditions are highlighted.

Dialect	Condition	Contrast	EMMeans	95% CI		*p*-value	Cohen's *d*
				Lower	Upper		
Bokmål	Gender	Non-Agr. − Agr.	1.56	1.19	1.93	< .001	0.265
Northern Norwegian	Gender	Non-Agr. − Agr.	1.10	0.73	1.48	< .001	0.187
Bokmål	Number	Non-Agr. − Agr.	0.40	0.03	0.78	.033	0.068
Northern Norwegian	Number	Non-Agr. − Agr.	−0.25	−0.62	0.13	.196	−0.042

in Bokmål but ungrammatical in Northern Norwegian dialect, and conversely number *non-agreement* (zero-marking) is grammatical in Northern Norwegian but ungrammatical in Bokmål (e.g., Bokmål *hund-ene var snill-e/*snill* but Northern Norwegian *hund-an va *snill-e/snill* "the dogs-DEF.PL. were kind-PL./∅"). Experiments 2–3 thus test to what extent individual bilectals show processing differences depending on the linguistic input (Bokmål vs. their native-spoken dialect).

In the gender (congruent) condition, both Bokmål and Northern Norwegian varieties feature equally categorical masculine/neuter gender agreement (e.g., *the dog-*M. *is kind-*M./*N.), and participants display large P600 effects associated with gender non-agreement in both modes. Estimated marginal means (Table 5) reveal the differences in amplitude between gender agreement and non-agreement trials are comparable between modes (Bokmål mode — emmeans, difference: 1.56 µV ± 0.19 SE, $p < .001$, Cohen's $d = 0.265$; Northern Norwegian mode — emmeans, difference: 1.10 µV ± 0.191 SE, $p < .001$, Cohen's $d = 0.187$).

In the number (incongruent) condition, where participants' spoken dialect and Bokmål are grammatically contrastive, amplitude differences in the P600 window have opposite polarity but are significantly reduced in both modes, further highlighting the interaction between participants' contrasting spoken dialect and Bokmål grammars (Bokmål mode — emmeans, difference: 0.40 µV ± 0.19 SE, $p = .033$, Cohen's $d = 0.068$; Northern Norwegian mode — emmeans, difference: −0.25 µV ± 0.191 SE, $p = .196$, Cohen's $d = -0.042$). As explored in greater detail in the individual differences analyses below, this attenuation in P600 effects in bilectally grammatically incongruent conditions is indicative of the significant within-group variation, modulated by individual bilectal experience, which is masked at the group level in grand average waveforms.

Individual ERP differences

The differences in responses to cross-dialectally non-contrastive gender versus contrastive number agreement marking in Fig. 6 suggest

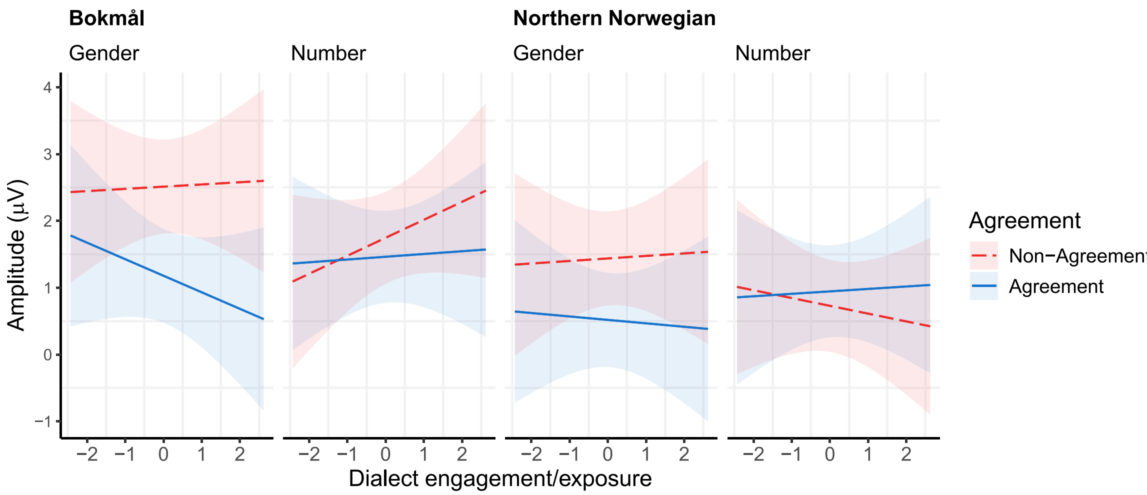

Fig. 7. Predicted P600 amplitude values for gender and number agreement in Bokmål and Northern Norwegian modes at differing individual levels of dialect engagement/exposure (*z*-scored).

Table 6
Estimated slopes with 95% confidence intervals (CI), significance, and effect sizes between dialect modes for gender and number conditions. The shaded rows highlight Bokmål–dialect grammatically incongruent number conditions.

Dialect	Condition	Contrast	Slope	95% CI		*p*-value	Cohen's *d*
				Lower	Upper		
Bokmål	Gender	Non-Agr. – Agr.	0.281	0.176	0.385	< 0.001	0.048
Bokmål	Number	Non-Agr. – Agr.	0.228	0.123	0.332	< 0.001	0.039
Northern Norwegian	Gender	Non-Agr. – Agr.	0.089	−0.038	0.216	0.168	0.015
Northern Norwegian	Number	Non-Agr. – Agr.	−0.153	−0.280	−0.027	0.018	−0.026

that participants' processing of grammatical patterns are mutually influenced by bilectal grammatical in/congruency in both Bokmål and dialect modes. Alike the individual differences analysis of the Bokmål experiments 1–2, we ran a corresponding LMM to tease apart how the results above may vary at the individual level in relationship to dialect and Bokmål use and exposure. This model includes item-level *Amplitude* averages within the 500–900 ms time window as the dependent variable, and fixed effects included two four-way interactions, each with*Agreement* (agreement, non-agreement), *Condition* (gender, number), *Dialect* (Bokmål, Northern Norwegian), and either *Bokmål engagement/exposure* or *Dialect engagement/exposure* composite factor scores to assess the mutual relationship between participants experience with their dialect and Bokmål on gender and number agreement processing in each mode. As with the other models above, a second three-way interaction incorporating *Age*, *Agreement*, and *Dialect* was included to help control for aging effects on ERP non-/agreement amplitudes (cf., Caplan et al., 2011; Dorme et al., 2023; Xu et al., 2017). Age as well as linguistic experiential factor scores were scaled using *z*-scoring, and all factors were coded using treatment contrasts. The model's random structure incorporated random intercepts for *Item*, *Subject*, and *Electrode*, as well as by-subject random slopes for *Condition* to account for potential individual variability in responses to gender vs. number agreement violations.

Focusing on relevant interactions in this model, a significant four-way interaction was found between *Agreement*, *Condition*, *Dialect*, and *Bokmål engagement/exposure* (0.819 ± 0.140 SE, $p < .001$), but the four-way interaction involving *Dialect engagement/exposure* was not significant overall (0.190 ± 0.114 SE, $p = 0.096$). To investigate the more specific influence of dialect engagement/exposure in grammatically congruent and incongruent conditions, estimated trends (emtrends) were calculated to determine the slopes of dialect engagement/exposure for each condition in each dialect mode (Table 6). Amplitude prediction values for the four-way interaction between *Dialect*, *Condition*, *Agreement*, and *Dialect engagement/exposure* are presented in Fig. 7. For corresponding analyses of Bokmål engagement/exposure in the Bokmål mode, see Fig. 3, as well as the full model summary and additional statistics in our analysis script on OSF.

These results reveal that dialect engagement/exposure composite factor scores predict individual differences in P600 amplitudes in the target number condition in both modes (Bokmål — emtrends: 0.228, 95% CI[0.123, 0.332], $p < 0.001$; Northern Norwegian — emtrends: −0.153, 95% CI[−0.280, −0.027], $p < 0.05$). Notably, increased dialect engagement/exposure has opposite effects in the two modes, reflecting the differing grammaticality of number agreement in each variety. Specifically, greater dialect engagement/exposure is associated with larger P600 amplitudes for number *non-agreement* in Bokmål and for number *agreement* in the Northern Norwegian mode. Additionally, greater dialect engagement/exposure is linked to increased amplitude responses in the gender condition in Bokmål (emtrends: 0.281, 95% CI [0.176, 0.385], $p < .001$) but not for the Northern Norwegian mode (emtrends: 0.089, 95% CI [−0.038, 0.216], $p = 0.168$). The significant influence of dialectal use and exposure in both conditions in the Bokmål mode suggests that increased dialectal experience is associated with higher magnitude differences overall.

In summary, participants in the Bokmål–Northern Norwegian bilectal processing experiments exhibit robust P600 effects of non-agreement in the gender control conditions. In grammatically incongruent number trials, participants show attenuated P600 effects in both modes, reflecting the mutual influence of contrasting Bokmål and Northern Norwegian morphosyntax on bilectal sentence processing. Similar to the influence of individual Bokmål experiential factors on individual variability in ERPs during Bokmål sentence processing, the effects above are significantly modulated by individual levels of dialect engagement and exposure. These findings underscore the complexity and importance of bilectal experience in navigating grammatical incongruities between closely related linguistic varieties.

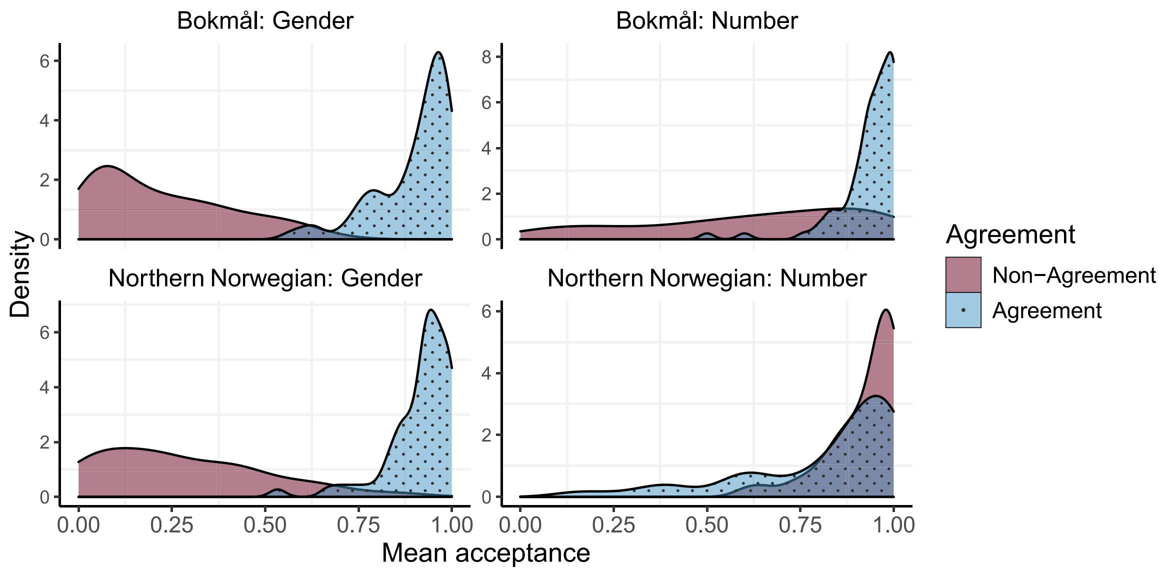

Fig. 8. Mean acceptance density plots for gender and number non-/agreement in Bokmål and Northern Norwegian dialect modes.

Behavioral results

Fig. 8 presents the corresponding outcomes of the grammaticality judgment tasks among Northern Norwegian participants in the Bokmål and Northern Norwegian modes. Participants were instructed to base their grammaticality judgments on whether the relevant sentence conforms to Bokmål orthographic rules in the Bokmål mode and on whether they believed the sentence to be a well-formed sentence in Northern Norwegian dialect in the Northern Norwegian mode. As with experiments 1–2, participants with well below chance accuracy (< 35%) on gender control conditions have been removed from further analysis. This led to the removal of 2 subjects with low accuracy in both Bokmål and Northern Norwegian sessions, leading to 4 rejected sessions. The final participant numbers for the two dialect modes are: Bokmål (n = 81) and Northern Norwegian (n = 66). As with experiments 1–2, we assessed the consistency of participants' responses by comparing acceptance rates from the first half of the experiment to those from the second half, and found no significant changes in behavior over the course of the experiment.

The behavioral results in Fig. 8 broadly replicate the patterns we observed in the ERP analyses above: participants clearly distinguish cross-dialectally uniform gender non-/agreement grammaticality in both variety modes, but acceptability rates are more mixed in the number condition, especially in the Northern Norwegian mode. To better clarify these patterns, we ran a mixed-effects logistic regression model with the same structure as the corresponding GLMM in Section g but here testing the interaction between *Agreement*, *Condition*, and *Dialect*, which was revealed to be significant ($p < .001$). Post-hoc tests using estimated marginal means (emmeans) revealed significant differences in grammaticality judgments between the two dialect modes with significantly higher acceptance of number agreement compared to non-agreement in the Bokmål mode (emmeans, difference: 1.544 ± 0.212 SE, $p < .001$) and conversely significantly lower acceptance of number agreement compared to non-agreement in the Northern Norwegian mode (emmeans, difference: −2.347 ± 0.209 SE, $p < .001$), as expected given the reversed grammaticality of plural number marking between the two varieties. Finally, comparing group differences in acceptance of gender agreement minus non-agreement marking reveals no significant difference (emmeans, difference: 0.15 ± 0.134 SE, $p = 0.260$), suggesting that gender non-/agreement marking is judged analogously across the two modes. By contrast, in the number condition, where we lack this cross-dialectal structural overlap, there are substantial differences in non-/agreement grammatical judgments between the two sessions (emmeans, difference: 3.89 ± 0.393 SE, $p < .001$).

The relatively high acceptance of both plural marking and zero-marking in the Northern Norwegian mode is somewhat surprising, and it is important here to note that these patterns are not optional in Northern Norwegian dialects. This is evident both in dialectal surveys (e.g., Sandøy, 1988; cf., also Åfarli & Vangsnes, 2020) as well as the production tasks in Kubota et al. (2023) and the present study which test participants' use of number agreement, revealing a consistent absence of predicate number agreement in their spoken dialect. In other words, the behavioral results described here do not reflect some ongoing dialect change or existing optionality, and these patterns are not found in spoken language production: predicate plural number agreement marking is obligatory and categorical in Bokmål and zero-marking (non-agreement) is a highly salient, categorical, and obligatory feature of Northern Norwegian dialects, despite the apparent gradience in these acceptability judgment tasks. There are thus apparently significant differences between the production and perception of predicate plural number marking in this population. Given the replication of these effects across the two dialect modes and in both ERP and behavioral responses, it is most likely that these effects relate to the bilectal contrastivity of this grammatical feature (i.e., the result of mutual influence and interference between Bokmål and Northern Norwegian dialect in each mode).

Individual behavioral differences

To further explore how these results might be influenced by extra-linguistic factors such as participants' engagement/exposure to their dialect and Bokmål, we fitted an additional generalized linear mixed-effects model. This model includes *Acceptance* (accept, reject) as the dependent variable, using a binomial family with a logit link function. The model included the same fixed effects and same interactions as the corresponding LMM outlined in the ERP analysis in above with four-way interactions, each comprising *Agreement* (agreement, non-agreement), *Condition* (gender, number), *Dialect* (Bokmål, Northern Norwegian), and then either *Dialect engagement/exposure* composite factor scores or *Bokmål engagement/exposure* composite factor scores (both z-scored). As with the other models above, a three-way interaction between *Age*, *Agreement*, and *Dialect* was included to capture age-related differences in sensitivity to agreement condition differences in each dialect mode. All factors were coded using treatment contrasts. *Subject* and *Item* were included as random intercepts and *Condition* as

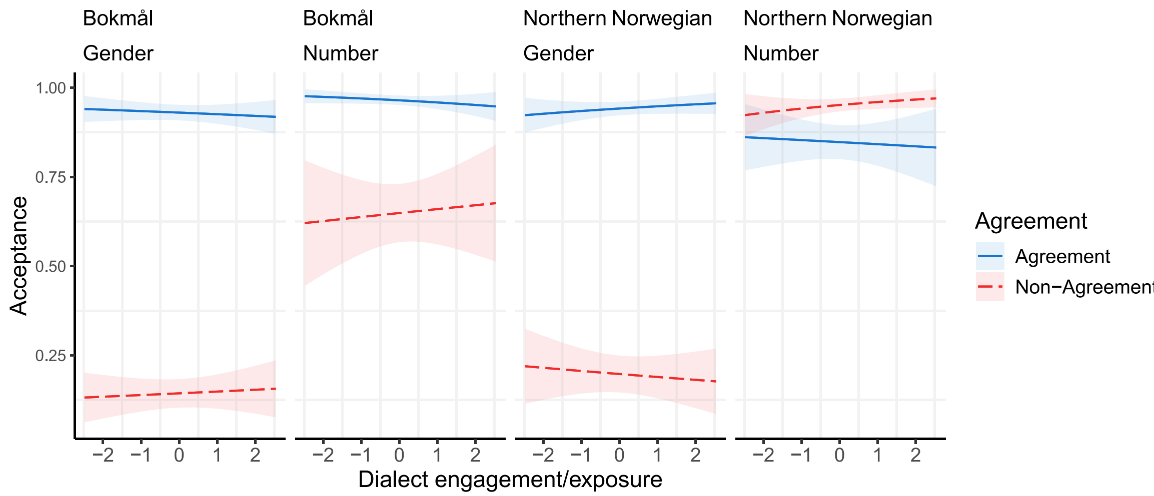

Fig. 9. Predicted acceptance levels for gender and number agreement in Bokmål and Northern Norwegian modes at differing individual levels of dialect engagement/exposure (z-scored).

Table 7
Estimated slopes with 95% confidence intervals (CI), significance, and effect sizes for dialect engagement/exposure for gender and number conditions between Bokmål and Northern Norwegian dialect modes. The shaded rows highlight bilectally contrastive number conditions.

Dialect	Condition	Contrast	Slope	95% CI		p-value	Cohen's d
				Lower	Upper		
Bokmål	Gender	Agr. − Non-Agr.	−0.107	−0.277	0.063	0.218	−0.107
Bokmål	Number	Agr. − Non-Agr.	−0.212	−0.388	−0.036	0.018	−0.212
Northern Norwegian	Gender	Agr. − Non-Agr.	0.173	−0.028	0.373	0.091	0.173
Northern Norwegian	Number	Agr. − Non-Agr.	−0.242	−0.444	−0.040	0.019	−0.242

a by-subject random slope. Acceptance prediction values for *Dialect engagement/exposure* are presented in Fig. 9.

There were significant interactions between *Agreement*, *Condition*, *Dialect* (3.71 ± 0.431 SE, p < .001); *Agreement*, *Dialect*, and *Age* (0.543 ± 0.109 SE, p < .001); *Dialect*, *Agreement*, and *Dialect engagement/exposure* (−0.280 ± 0.131 SE, p = .033). Four-way interactions including *Dialect engagement/exposure* factor scores (0.309 ± 0.187 SE, p = .098) and *Bokmål engagement/exposure* (0.108 ± 0.248 SE, p = .662) were found to be non-significant overall. However, as with earlier models, this is not unexpected since it is predicted that bilectal linguistic experience should only significantly influence results in bilectally contrastive conditions. Analogous to the earlier analyses in this paper, emtrends were therefore calculated to examine how individual dialect and Bokmål engagement/exposure might shape acceptability judgments under specific conditions of interest. The emtrends for dialect engagement/exposure are presented in Table 7; corresponding emtrends for Bokmål engagement/exposure in the Bokmål mode are available in Section g and in our analysis script on OSF.

These results reveal that dialect engagement/exposure composite factor scores predict marginal individual differences in number non-/agreement acceptability judgments in both modes (Bokmål — emtrends: −0.212, 95% CI [−0.388, −0.036], p = 0.018; Northern Norwegian — emtrends: −0.242, 95% CI [−0.444, −0.040], p = 0.019). Specifically, higher dialect engagement/exposure is associated with more discrete judgments in the Northern Norwegian mode with higher acceptability of non-agreement marking (grammatical in Northern Norwegian). By comparison, Northern Norwegian bilectals show slightly less discrete (and less accurate) judgments in the Bokmål mode with increasing dialect engagement/exposure. Notably, this stands somewhat in contrast to the ERP results, where increasing dialect experience was associated with increased P600 amplitudes in both Northern Norwegian and Bokmål modes (Fig. 7).

In the gender condition, as expected, dialect engagement/exposure has no significant effect on acceptability judgments in either mode (Bokmål — emtrends: −0.107, 95% CI [−0.277, 0.063], p = 0.218; Northern Norwegian — emtrends: 0.173, 95% CI [−0.028, 0.373], p = 0.091), suggesting that individual dialect experience is less relevant in bilectally non-contrastive conditions.

Discussion

This study aimed to better understand the nature of bilectalism and bilectal grammatical processing. To that end, we employed three ERP reading comprehension experiments in two dialect regions (Sunnmøre, Northern Norway) and in two Norwegian modes (Bokmål, Northern Norwegian dialect). These experiments tested both dialect-specific and non-contrasting grammatical conditions. Masculine versus neuter gender agreement on predicate adjectives, which is common to all Norwegian varieties, served as the control condition, and plural number agreement on predicate adjectives, which is grammatical in Sunnmøre Norwegian dialects and Bokmål but not in Northern Norwegian, served as the target condition. Using this combination of contrasting and non-contrasting grammatical patterns, tested in distinct dialect regions and in multiple dialect modes with variable grammatical congruency, allows one to distinguish (i) to what extent bilectals acquire distinct linguistic representations for narrow grammatical differences in closely related varieties of a language with which they have sufficient engagement/exposure, (ii) how contrasting, dialect-specific grammatical patterns interact in bilectal processing, and (iii) how individual bilectal engagement and exposure may modulate grammatical processing in bilectal contexts.

Fig. 10 summarizes the ERP results of the three experiments, providing non-agreement minus agreement difference waves for each condition in each experiment. These difference waves serve to isolate the effects of gender and number non-agreement and how these effects vary depending on the dialect mode (Bokmål, Northern Norwegian) and in relationship to grammatical differences in each dialect region (Sunnmøre, Northern Norway). In the gender control condition where

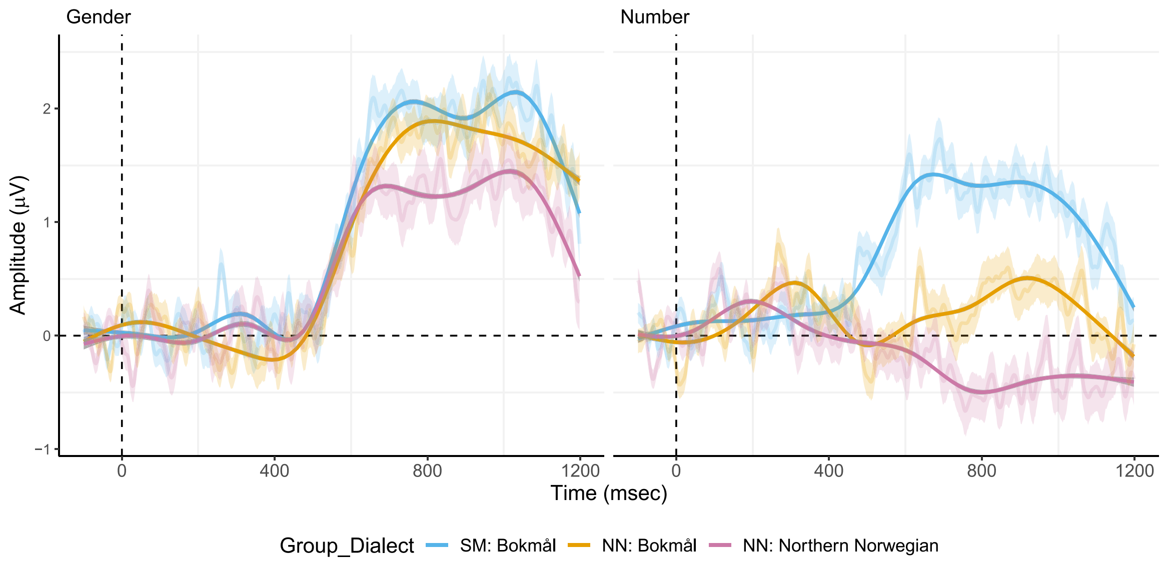

Fig. 10. Non-agreement minus agreement difference waves at central, parietal, and occipital electrodes for gender and number conditions for each group and each variety (SM = Sunnmøre, NN = Northern Norway). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

all the tested spoken and written varieties are grammatically aligned, we observe consistent P600 responses of roughly equal amplitude in ungrammatical non-agreement trials, indicating uniform processing of grammatical congruities across each group and each variety.

By contrast, the number condition reveals systematic differences between the two dialect groups and two Norwegian modes. The Sunnmøre (control) group shows a P600 effect for Bokmål number non-agreement, analogous to the gender control condition, reflecting these dialect speakers' grammatical alignment with Bokmål in gender and plural number marking. Conversely, the Northern Norwegian (target) group, with contrasting number non-/agreement grammaticality to Bokmål, present significantly attenuated P600 responses in both modes when compared to both the gender control condition and the Sunnmøre control group, evidencing the mutual influence of their contrasting spoken dialect and Bokmål grammars, reminiscent of cross-linguistic effects observed in many bilingual processing studies where cross-linguistic dissimilarities are similarly associated with the attenuation or absence of processing responses (e.g., Alemán Bañón et al., 2018; Caffarra et al., 2015; Dowens et al., 2010; Foucart & Frenck-Mestre, 2011; Martohardjono et al., 2017; Rossi et al., 2006; Sabourin & Stowe, 2008; White et al., 2012). Finally, the polarity of Northern Norwegian participants' P600 non-agreement minus agreement difference waves is reversed for Bokmål (positive going) and Northern Norwegian modes (negative going). This reversal is expected and indicative of the diametric opposition in the grammaticality of plural number agreement marking between Bokmål (ungrammatical non-agreement) and Northern Norwegian (ungrammatical agreement). These contrasting responses between Bokmål and Northern Norwegian modes provide clear evidence that bilectals do develop distinct grammatical representations for dialect-specific grammatical differences and apply them differentially, adjusting their processing strategies depending on the dialect input.

The group-level patterns outlined above however mask significant individual variability. In both on-line (ERPs) and off-line measures (grammatical acceptability judgments), we observe substantial individual differences in grammatically incongruent conditions, relating to differences in subjects' individual bilectal linguistic experience. In fact, depending on the degree of use of and exposure to dialect writing and Bokmål, subjects may even display diametrically opposed processing patterns (i.e., inverse P600 effects) and reversed grammaticality judgments, which have a canceling out effect at the aggregate level (leading to the reduced P600 amplitudes in Fig. 10 above).

Given the gradience of these individual differences, it would be reasonable to ask whether such group and individual differences indicate some degree of linguistic uncertainty and/or poor meta-linguistic awareness among Northern Norwegian participants. In other words, to what extent do these results reflect speakers who have un(der)specified grammatical representations or who are unsure of what form belongs to Bokmål versus their spoken dialect? In L2 learning contexts, decreased experimental effects among L2-learners compared to L1-speakers are often interpreted as indicating less robust processing and more uncertain, weaker, and/or underspecified grammatical representations (Alemán Bañón et al., 2018; Caffarra et al., 2017; Dowens et al., 2010; Foucart & Frenck-Mestre, 2011; Martohardjono et al., 2017; Rossi et al., 2006; Sabourin & Stowe, 2008). However, our context of bilectalism — testing populations traditionally considered monolingual — is quite distinct from L2 learning contexts, and it is important in this regard to note that we only have evidence for these differences in comprehension measures. When speaking their dialect, Northern Norwegian participants consistently display predicate plural number zero-marking (as recorded by our spoken sentence reading task), and there is no evidence that Northern Norwegians show variability or experience difficulty in implementing number agreement when writing in Bokmål. This suggests that the variability we see in bilectals' ERPs and acceptability judgments is not matched in language production, which would be expected if these effects were due to weaker or underspecified grammatical representations.

Instead, we believe these results are consistent with a linguistic architecture which includes integrated dialect- (and language-)specific grammatical sub-networks with competing activation (e.g., Blanco-Elorrieta & Caramazza, 2021; Goldrick et al., 2016). Under this account the activation and selection of dialect- and language-specific morphosyntactic features in production and perception may be modulated by a wide range of factors: e.g., grammatical and lexical frequency; the speaker/listeners' engagement, exposure, and proficiency in each variety; and other extra-linguistic variables such as temporal effects (recency of use), register, communicative context, etc. The result is a spectrum of cross-dialectal influence in dialectally contrastive grammatical contexts with highly graded individual variation.

The interaction between such closely related, and likely therefore such highly co-activated, varieties as Northern Norwegian and Bokmål makes important contributions to our understanding of the role of cross-linguistic influence in sentence processing. In the L2 literature, meta-analyses reveal that cross-linguistic differences have in general limited or unclear influence on syntactic processing (cf., Caffarra et al., 2015; van Dijk et al., 2022; Lago et al., 2020). As pointed out by Lago et al. (2020), however, the interpretation of CLI effects in the L2 literature is not always straightforward since between-group designs involving separate languages introduce potential confounds that can be difficult to control for. First, operationalizing "grammatical similarity" across languages is not trivial (is masculine in French [a two-gender system] the same as masculine in German [a three-gender system]?), and even for more straightforward cases, linguistic materials and conditions across languages may still vary in their complexity, frequency, use, and markedness. Finally, traditional comparisons between L1 and L2 speaker groups may differ with regard to other individual variables which predictably influence processing, such as engagement, exposure, proficiency, age of acquisition, working memory capacity, etc. (Kotz, 2009). By contrast, our context of bilectalism allows this investigation to combine both between- and within-subject designs, testing both grammatically congruent and incongruent conditions between distinct L1 varieties with which the target speaker population (Northern Norwegians) all have predictably high engagement, exposure, and proficiency (their L1). This approach allows us to isolate the specific effects of grammatical dis/similarity on morphosyntactic processing much more precisely than is typically possible in other bilingual contexts. Our results show clearly that grammatical dis/similarity between linguistic varieties has substantial — though still highly individualized — effects on processing, even between closely related varieties of the same language.

These data suggest that bilectalism is fundamentally not different from other forms of bilingualism, and the same mechanisms involved in managing and processing contrasting bilingual linguistic representations in production and perception are active at the unilingual level — only the degree of linguistic variation at hand is smaller given the typological proximity of mutually intelligible dialects. We do not observe evidence of some lower typological threshold constraining grammatical acquisition; given sufficient engagement and exposure, even subtle linguistic differences between closely related varieties, like those we have tested, may be acquired, represented, and applied differentially in language processing in bilectal contexts. In sum, these findings collectively suggest that bilectalism is a proper sub-case of bilingualism.

CRediT authorship contribution statement

Jade Sandstedt: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Maki Kubota:** Writing – review & editing, Visualization, Methodology, Investigation, Formal analysis. **Merete Anderssen:** Writing – review & editing, Methodology, Funding acquisition. **Jeannique Anne Darby:** Writing – review & editing, Investigation. **Stig Helset:** Writing – review & editing, Investigation. **Elahe Tavakoli:** Investigation. **Øystein A. Vangsnes:** Writing – review & editing, Methodology, Funding acquisition. **Jason Rothman:** Writing – review & editing, Resources, Methodology, Funding acquisition.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Jade Sandstedt reports financial support was provided by Volda University College. Jade Sandstedt reports financial support was provided by Aurora Centre for Language Acquisition, Variation and Attrition, UiT - The Arctic University of Norway. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data, stimuli, questionnaires, and the analysis script are available in the Open Science Framework at: https://osf.io/htjxw/?view_only=5f9df38c10b747e4945f977f5f84eeef.

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Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jml.2024.104557.

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