The role of grammatical alignment, engagement, and exposure in cross-dialectal influence on bilectal processing

Jade Sandstedt[1,2], Maki Kubota[2], Merete Anderssen[2], Jeannique Anne Darby[1], Stig Helset[1], Yanina Prystauka[2], Jason Rothman[2,4], Elahe Tavakoli[1], and Øystein Vangsnes[2,3]

1Volda University College
2UiT – The Arctic University of Norway
3Western Norway University of Applied Sciences
4Universidad Nebrija

jade.jorgen.sandstedt@hivolda.no

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1 Background

This project explores Bilectalism and bilectal processing

Bilectalism: refers to a context where individuals – bilectals – acquire two (vernacular) varieties (e.g. Northern and Western Norwegian) and/or one or more written varieties of the same language (e.g. Norway's two official written languagegs Nynorsk and Bokmål)

Main questions and main findings

Bilectals acquire linguistic systems which are alike in most domains but which can vary in lexicon, morphosyntax, and/or phonology

The goal with this project is to better document bilectalism and effects of dialect use/alignment on bilectal literacy:

- how empirically dis/similar is bilectalism from other types of multilingualism?
- to what extent do bilectals operate with distinct grammatical representations?
- how do conflicting (misaligned) grammatical features interact in bilectal processing?
- how is the processing of written languages (e.g. Bokmål) influenced by one's dialect?

While there has been some neurocognitive research on bilectalism, most of this research has focussed on phonetic/phonological and semantic processing (e.g. Bühler et al. 2017; Goslin, Duffy and Floccia 2012; Lanwermeyer et al. 2016; Martin et al. 2016)

- we know relatively little about how bilectals represent and process grammatical differences between the different dialects they are exposed to
- we know especially little about how the brain processes morphosyntactic information in bilectal contexts

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Main findings (on-going): Our studies (on-going) suggest that bilectalism is a true sub-case of bilingualism

- processing of dialect-specific features is modulated by exposure to the specific dialect (something similar to L2-Learning)
- bilectals adjust their processing strategies according to the dialectal input (Distinct Bilectal Grammatical Representations)
- conflicting/misaligned grammatical features interact in bilectal processing (Cross-Dialectal Influence on Bilectal Processing)

1.1 Bilectal grammatical variation

In some cases, two closely related linguistic varieties can display conflicting or misaligned grammatical features

- e.g. number non-/agreement on predicate adjectives in Northern Norwegian, Sunnmørsk, and Bokmål ('the cars are red'-∅/-PL) (1)

(1) **Number agreement in Northern Norwegian, Sunnmørsk, and Bokmål**
bilan   e   rød/*rød-e   **Northern Norwegian**
bilane   e   *raud/raud-e   **Sunnmørsk**
bilene   er   *rød/rød-e   **Bokmål**

In this study, we focus on such aligned and misaligned agreement patterns

☞ these situations where one structure is grammatical in one variety but ungrammatical in another are ideal for studying how grammatical representations interact in the minds of bilectals

2 Methods – electroencephalography (EEG) and the ERP-technique

To get a picture of how language users process linguistic input in bilectal contexts, we use electroencephalography (EEG) to measure the brain activity of speakers while they read sentences with different grammatical features in different varieties (specifically, Northern Norwegian vs. Bokmål)

(a) A Northern Norwegian participant during experimental preparation
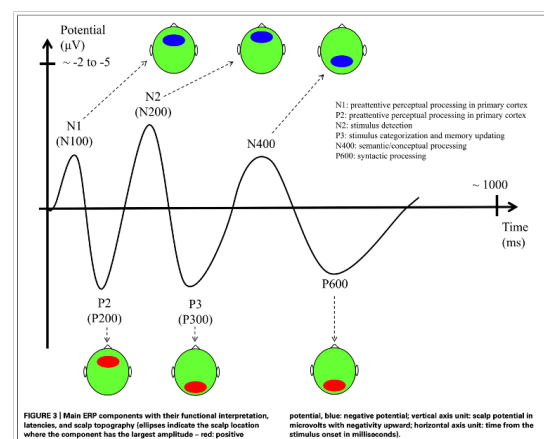
(b) Main ERP-components and their functional interpretations

Figure 1: EEG-measurement and event-related potentials (ERPs)

Figure 1 shows a picture of one of the participants in Tromsø before she begins the experiment

- the electrodes on the scalp pick up electrical activity generated in the brain
- measuring the electrical activity generated by the synchronised activity of thousands of neurons
- very good temporal resolution (insights into processing in real time)

Figure 1b gives an idealised example of the main ERP components (*event-related potentials*, ERPs); negative is plotted up

- N400 – negative deflection in the waveform which tops out around 400 ms after the stimuli; often used in investigations of semantic processing
- P600 – positive deflection in the waveform which starts around 600 ms after the stimuli; related to morphosyntactic processing, which increases when one processes grammatical errors

2.1   Event-related potentials (ERPs)

In this study, we analyse how the brain responds to different grammatical inputs by use of EVENT-RELATED POTENTIALS (ERPs)

Event-related potentials (ERP): the measured brain response a specific sensory, cognitive, or motor event

- e.g. how the brain responds to a specific (in/correctly inflected) word in a sentence

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ERPs thus refer to positivity or negativity (deflections) in the waveform which begins or tops out around a certain time following a stimuli of interest

Time-locking ERPs

In our studies, we use so-called RAPID SERIAL VISUAL PRESENTATION (e.g. Figure 2)

- participants read a sentence where each word is presented alone in consistent intervals (450 ms)
- ergo, we know precisely when the participant saw the critical word (e.g. an adjective of interest)
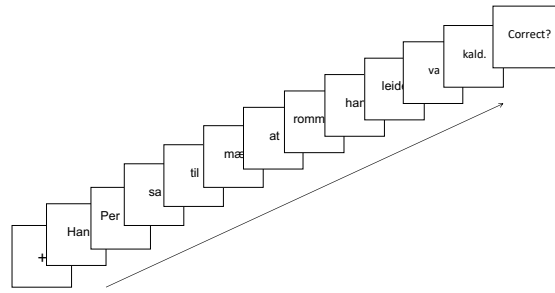
Figure 2: Sentences are presented word for word (Rapid Serial Visual Presentation)

Following each sentence, the participants are also tasked with determining whether the sentence was correct or incorrect

- with this we can investigate potential differences between the participants' neurocognitive and behavioural responses (what they consciously think about the grammar)

The P600-effect and Norwegian adjective inflection

Below we see what this looks like in reality (Figure 3)

- the ERP is time-locked to the start of the adjective (e.g. *eleven var frekk/frekt* 'the student (M.) was rude-M./N.)'
- we see a P600 for both sentences (positivity in the waveform which starts around 600 ms following the start of the adjective)
    - this is evidence of morphosyntactic processing in both sentences
    - as expected, the P600 ERP increases in ungrammatical sentences (e.g. *eleven var *frekt*), showing increased activity related to the processing of a violation of a grammatical rule
    - ☞ provides a direct indication of a grammatical rule of obligatory gender agreement
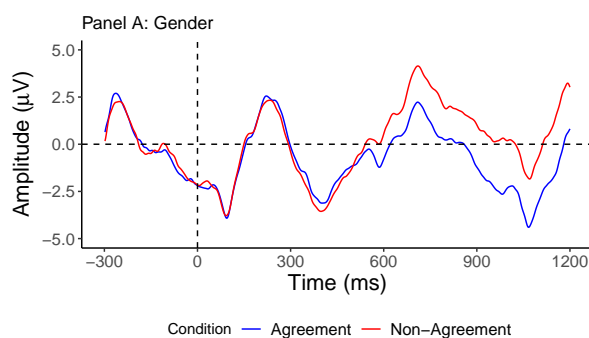

Figure 3: ERP-waveforms, recorded at electrode Pz (midline posterior) from participants while reading sentences with agreement (blue) and without agreement (red) in Northern Norwegian dialect writing

3 The experiments – bilectal processing in Northern Norway and Sunnmøre

This project consists of three experiments

1. Experiment 1   processing of Northern Norwegian dialect by Norwegians in Tromsø
   - testing both Northern and Southern Norwegians with varied exposure to Northern Norwegian dialects
2. Experiment 2   Bokmål-processing by Northern Norwegians in Tromsø
3. Experiment 3   Bokmål-processing by Sunnmøre dialect speakers in Volda

3.1 Experiment 1 – dialect exposure modulates processing of dialect-specific features

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Experiment #1 in a nut-shell :

105 participants

- 56 Northern Norwegians
- 49 Non-Northern Norwegians (later arrivals to Northern Norway from other parts of Norway)
  - varying exposure to Northern Norwegian dialects – measured via an adapted Northern Norwegian *Language Social Background Questionnaire* (Anderson et al. 2018)

Testing in Northern Norwegian dialect writing

- focus on lack of number agreement on predicate adjectives in Northern Norwegian (obligatory in most other dialects)

Brain responses to Northern Norwegian-specific grammatical patterns are modulated by exposure to Northern Norwegian dialects

- ☞ with sufficient exposure, non-northerners show northern-like processing of number non-/agreement (something resembling L2-learning)
- ☞ one does not need to be born and raised with Northern Norwegian as a first language to process specifically Northern Norwegian grammatical features like a northerner

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Condition 1 – number agreement on predicate adjectives

Predicate adjectives do *not* display overt agreement in Northern Norwegian dialects

- the grammatical form is a bare stem, without inflection
- the opposite pattern of what we find in most other dialects; e.g. Bokmål in (3)[1]

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[1]Translation: 'Tor showed me that the apples he threw were full-∅/-PL. of worms'.

(2)   Han Tor viste mæ at eplan han kasta va full/*fulle av mark

(3)   Tor viste meg at eplene han kastet var fulle/*full av mark

Condition 2 – gender agreement on predicate adjectives

As a control, gender agreement on predicate adjectives was also tested (4).[2] Gender agreement (between masculine/feminine and neuter nouns) is a grammatical feature which is common to all Norwegian dialects and therewith expected to be processed similarly regardless of exposure to Northern Norwegian dialects

(4)   Ho Liv fortalte mæ at hunden ho trænte va snill/*snilt mot unga

Research questions

1. How do Northern Norwegians and non-northern Norwegians process gender and number agreement in Northern Norwegian dialect writing?
2. To what extent are potential individual differences modulated by one's first language and/or exposure to Northern Norwegian dialects?

3.1.1   ERP aggregate results

Figure 4 shows that both Nnrtherners and non-northerners show robust P600 effects of gender non-agreement (increased amplitude around 600 ms after the presentation of the adjective), but as expected, they show reversed P600-effects of number non-/agreement

- Northern Norwegians show increased amplitude in sentences with agreement (ungrammatical in Northern Norwegian)

    – NNorw   *eplan va full/*fulle av mark*
- Non-Northern Norwegians show increased amplitude in sentences without agreement (ungrammatical in the vast majority of other Norwegian dialects)

    – Bokmål   *eplene var fulle/*full av mark*

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[2]Translation: 'Liv told me that the dog she trained was kind-M./N. towards children'.
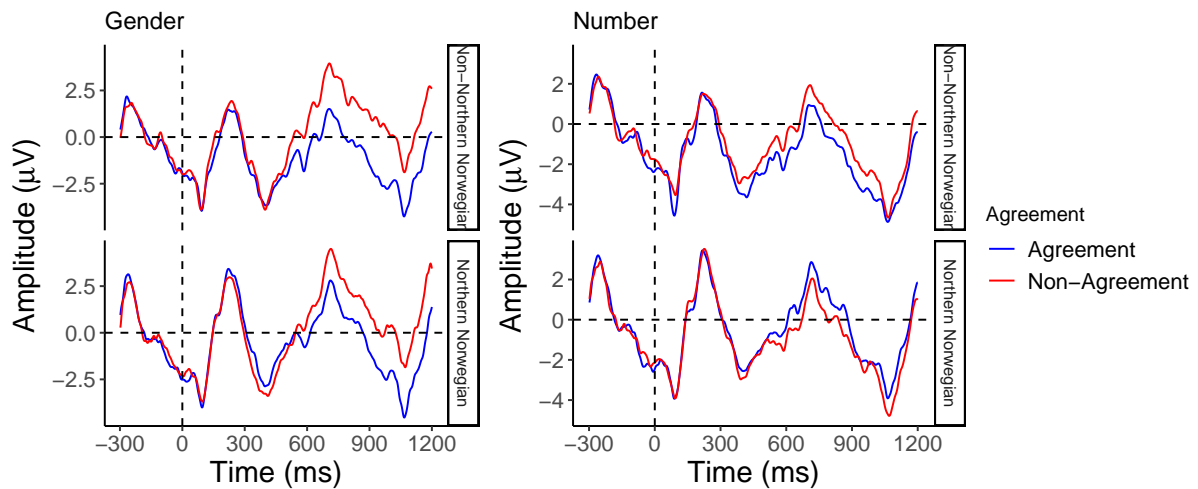
Figure 4: ERP waveforms recorded at electrode Pz for gender and number non-/agreement among Northern Norwegian and Non-Northern Norwegians while reading sentences with agreement (blue) and non-agreement (red) in Northern Norwegian dialect writing

3.1.2 Bilectal processing modulated by Northern Norwegian dialect exposure

The ERP analysis shows a significant interaction between *Group* (Northern Norwegian, non-Northern Norwegian) × *Agreement* (agreement, non-agreement) × *Exposure to NNorw* as summarised in Figure 5

- *composite c* = centralised LSBQ-score which represents the amount of use/exposure to Northern Norwegian dialects

Figure 5 shows the important effect of **exposure to Northern Norwegian** on Northern Norwegian language processing

- Northern Norwegians show consistently higher amplitude for sentences with number agreement – regardless of how much they use or are exposed to Northern Norwegian dialects

- Non-northerners process number agreement differently – according to how much exposure they have to Northern Norwegian dialects
  - the greater their exposure to Northern Norwegian, the more their processing patterns resemble Northern Norwegian processing (with higher amplitude in sentences with number agreement), otherwise they show the expected pattern with higher amplitude associated with sentences without agreement
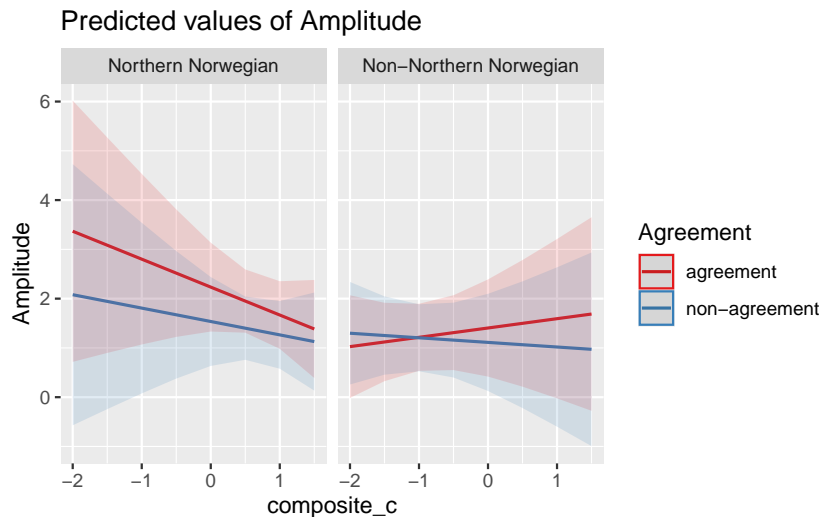
Figure 5: Predicted values illustrating the significant interaction between *Group* (NNorw, non-NNorw) × *Agreement* (samsvar, ikkje-samsvar) × *Exposure to NNorw* on number agreement (p < .001)

BILECTALISM AND DIALECT EXPOSURE:

- Processing of Northern Norwegian dialects is influenced by exposure to Northern Norwegian dialects: one does not need to be born and raised with Northern Norwegian to show Northern Norwegian-like processing strategies
- Similar to L2-learning, bilectalism exists on a contiuum where grammatical processing is modulated by an interaction of a wide spectrum of factors related to one's language background and engagement with the linguistic variety

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Open questions

So far we have only tested people in Northern Norway and only in one dialect

- do bilectals adjust their processing to other Norwegian dialects/varieties?

    - e.g. do their brain responses differ when processing obligatory number agreement in Bokmål?

In Norway, we have multiple Norwegian written languages (Nynorsk/Bokmål), and these have varying grammatical alignment with Norwegian dialects

- to what extent is processing of Norwegian written languages (i.e. Nynorsk/Bokmål) influenced by grammatical mis/alignment in Norwegian dialects?

3.2 Experiments 2 & 3 – cross-dialectal influence on bilectal processing

Experiment #2–3 in a nutshell:

125 participants (on-going)

- 53 Northern Norwegians
- 72 Sunnmøringar
  - adapted Northern Norwegian, Sunnmørsk, and Bokmål *Language Social Background Questionnaire* (Anderson et al. 2018) to map potential differences in exposure to the local dialect and/or Bokmål

Testing in Northern Norwegian dialect writing and Bokmål in Tromsø

- focus on individual differences in Northern Norwegian/Bokmål–bilectal processing of number agreement

Testing in Bokmål in Volda

- focus on cross-dialectal differences in processing of number agreement inflection on predicate adjectives and participles among Tromsø- and Volda-participants

Northern Norwegians show true bilectal processing, and Northern Norwegians and Sunnmøre participants' brain responses display cross-dialectal influence of their first language on Bokmål processing

- ☞ participants adjust their processing strategies according to the linguistic input (Northern Norwegian vs. Bokmål)
- ☞ Northern Norwegians show significant attenuation of their brain responses to number agreement in Bokmål (misaligned) compared to Sunnmøre participants (aligned)

3.2.1 Participants and conditions

The experiments were conducted with participants over 18 years of age, who have Norwegian as their first language – self-identifying as either Northern Norwegian or Sunnmørsk dialect speakers[3] – and who do not have known reading difficulties.

Group	Median age	Mean age	Mininum age	Maximum age
NNorwegian	32.0	37.0	18.1	77.6
Sunnmørsk	43.3	42.3	20.0	80.2

Table 1: Age distributions of Northern Norwegian and Sunnmørsk participants

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[3]Because of known geographic variation in participial agreement in Sunnmøre, we additionally required that participants have grown up in one of the following Sunnmøre counties: Volda, Ørsta, Vanylven, Herøy, Ulstein, Hareid, Sande, Sykkylven or Stranda.

Conditions – aligned and misaligned grammatical features

The Experiments consist of three conditions, described in Table 2

Condition	Agreement	Example	Bokmål	NNorw	Sunnmørsk
Adj.gen	agreement	*eleven er frekk*	✓	✓	✓
	non-agreement	*eleven er frekt*	✗	✗	✗
Adj.num	agreement	*husene er fine*	✓	✗	✓
	non-agreement	*husene er fin*	✗	✓	✗
Part.num	agreement	*lyktene er tente*	✗	✗	(✓)
	non-agreement	*lyktene er tent*	✓	✓	(✗)

Table 2: Conditions – common gender agreement, unique number non-agreement in NNorw, and unique participial number agreement in Sunnmørsk

The experiments test two critical conditions and one control:

- gender agreement on predicate adjectives

  ✓ common to all varieties
- plural number agreement on predicate adjectives

  ✗ NNorw is unique (lacks agreement)
- plural number agreement on predicate participles

  ✓ Sunnmørsk is unique (displays [optional] agreement)

Note: predicate participial number agreement is in decline in Sunnmøre. Figure 6 shows significant variation in the proportion of self-reported agreement in Sunnmørsk dialect writing in two recent short questionnaires. Here we thus expect modulation of responses by gender, age, geography, etc. These variables are mapped by the -questionnaires in the study, but the picture is more complex. Today we'll only focus on the processing of gender and number agreement on adjectives.
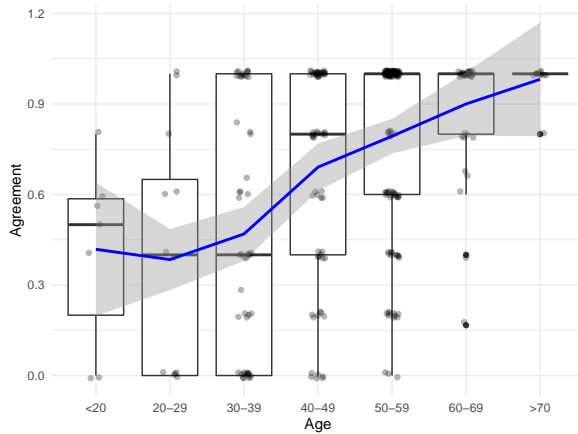
(a) Agreement by age (N = 297, mean = 0,711, SD = 0,454)
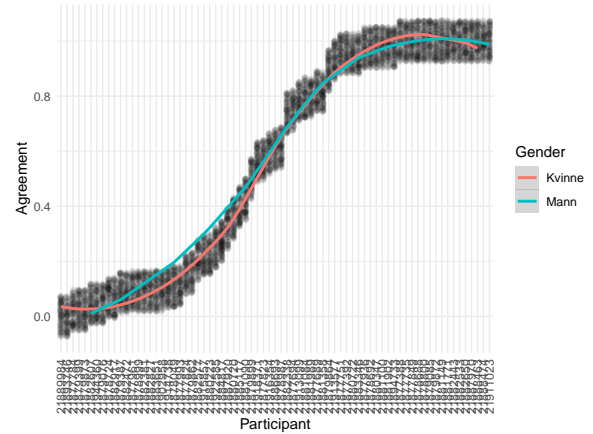
(b) Agreement by individuals (N = 73, mean = 0,556, SD = 0,497)

Figure 6: Variation in number agreement on predicate participles in Sunnmøre

3.2.2 ERP results

Condition 1 – gender agreement in Bokmål (control)

As expected, Northern Norwegians and Sunnmøringar display robust P600 effects of gender agreement in Bokmål (Figur 7)

- increased positive amplitude which starts around 600 ms for sentences without gender agreement
- ☞ a common grammatical feature for all three varieties, no cross-dialectal influence
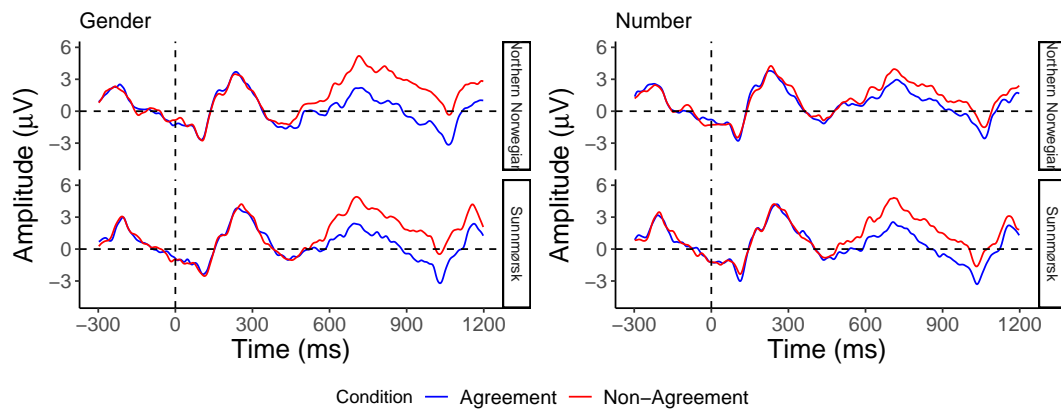

Figure 7: ERP waveforms recorded at electrode Pz for gender and number agreement among Northern Norwegian and Sunnmørsk participants while they read sentences with agreement (blue) and without agreement (red) in Bokmål. Northern Norwegians display significantly attenuated amplitude differences between non-/agreement trials in number vs. gender conditions.

Condition 2 – number agreement in Bokmål (critical)

And as expected, Sunnmøre participants show a large P600 effect of lack of agreement. A pairwise comparison test reveals no significant different between Gender and Number conditions for Sunnmørsk participants (estimate = 0.246, SE = 0.154, z.ratio = 1.599, p = 0.1099). As with gender agreement, both Sunnmørsk and Bokmål prohibit number **non**-agreement

- Bokmål   *bilene er *rød*
- Sunnmørsk   *bilane e *raud*

Conversely, in Figure 7, Northern Norwegian participants show significantly attenuated amplitude differences between agreement and non-agreement trials between Gender (control) and Number (target) conditions (estimate −1.319, SE = 0.164, z.ratio = −8.039, p < .0001).

These differences between Gender and Number processing likely relate to competition between Northern Norwegian and Bokmål morphosyntax. Northern Norwegian *prohibits* number agreement while Bokmål *requires* it

- Bokmål   *bilene er røde/*rød*
- NNorw   *bilan e *røde/rød*

CROSS-DIALECTAL INFLUENCE (CDI):

This means that sentences *with* and *without* agreement are grammatical and simultaneously ungrammatical for Northern Norwegians in one of their lects

- ☞ the Northern Norwegian ERP waveforms show a kind of *cancelling out*-effect of NNorw and Bokmål grammar, attenuating non-/agreement processing differences (CROSS-DIALECTAL INFLUENCE)

- ☞ CDI is not possible without distinct grammatical representations which are competition (TRUE BILECTAL PROCESSING)

Cross-dialectal influence and behavioural responses

We don't only see the effect of one's dialect in the brain responses in Figure 7. Cross-dialectal influences can also be detected in the participants' behavioural responses in Figure 8. Here we see that misaligned grammatical features between Bokmål and the participant's first language significantly weaken the participant's ability to detect grammatical errors in Bokmål sentences
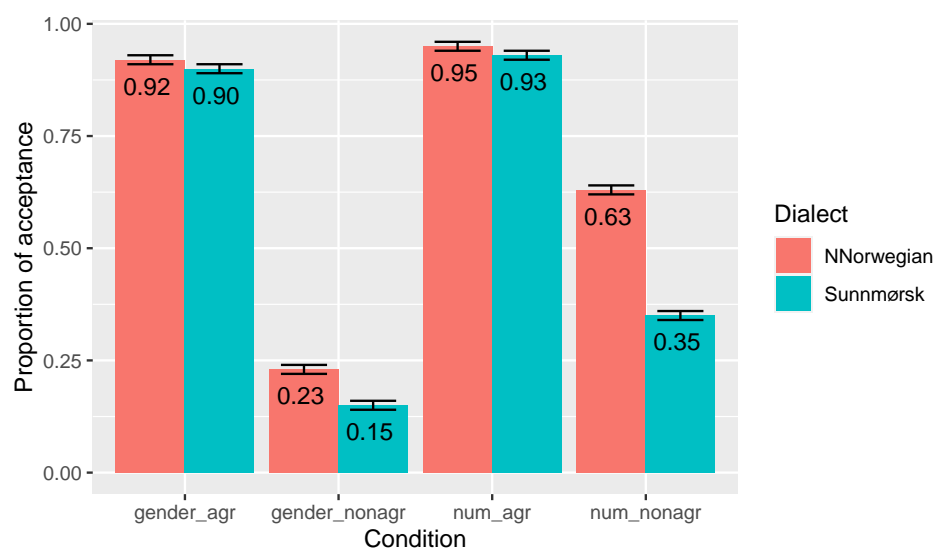
Figure 8: Significant effect of *Group* (Northern Norwegian, Sunnmørsk) on acceptance of number non-agreement in Bokmål

Northern Norwegian and Sunnmøre participants show equally high acceptance rates for gender agreement (mean = 0.92/0.90) og low acceptance of gender non-agreement (mean = 0.23/0.15)

☞ grammatical agreement between Bokmål and the dialects (control)

While both accept number agreement (mean = 0.95/0.93), we see large differences in the detection of number non-agreement

☞ Northern Norwegians show increased acceptance of adjectives *without* agreement (mean = 0.63, sd = 0.48) compared with Sunnmøre participants (mean = 0.35, sd = 0.48)

– nearly twice as high rates of acceptance

CROSS-DIALECTAL INFLUENCE ON BILECTAL PROCESSING:

These results suggest that cross-dialectal differences in bilectal contexts can have a large effect on the perception of bilectally varying grammatical patterns

☞ Northern Norwegians are nearly twice as bad at catching inflectional *errors* in Bokmål when these 'errors' are *grammatical* in their first language

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3.2.3 Bokmål reading processing and Bokmål engagement/exposure

The effects of grammatical misalignment are additionally modulated by Bilectal Experience

- which we can map using a Bokmål-adapted version of the *Language Social Background Questionnaire* (Anderson et al. 2018); designed to provide a continuous measurement of engagement with/exposure to Bokmål

Effects of dialect alignment on behavioural measures are modulated by Bokmål engagement/exposure

Figure 10 shows the results of a generalized linear mixed effects model (GLMM) investigating the relationship between grammatical judgements (*Acceptance*) and the four-way interaction *Group* (NNorwegian, Sunnmørsk) × *Condition* (gender, number) × *Agreement* (Agreement, non-agreement) × *Composite* (a centered score for Bokmål engagement/exposure), while controlling for the subject-specific random effects of *Agreement* and *Condition*.
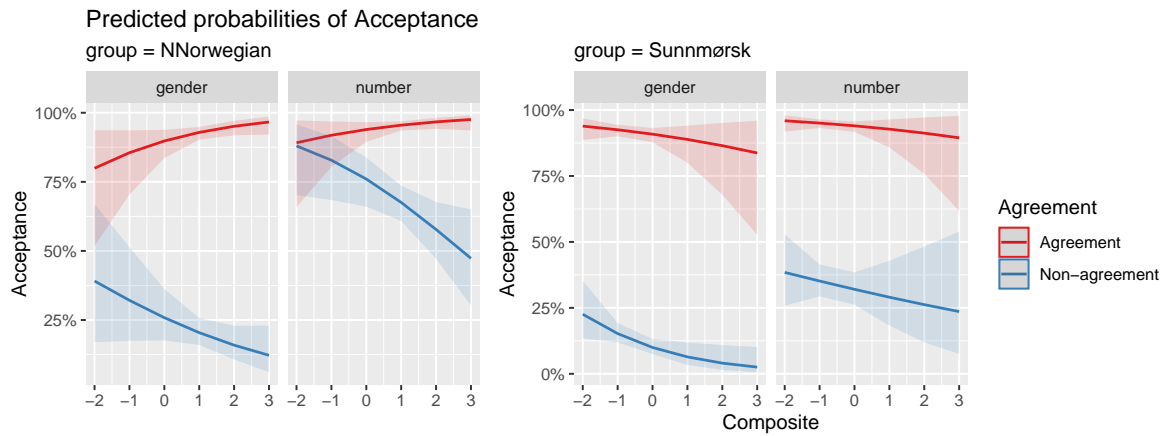

Figure 9: Predicted values illustrating the interaction between *group* (NNorwegian, Sunnmørsk) × *Condition* (gender, number) × *Agreement* (Agreement, non-agreement) × *Composite* (Bokmål engagement/exposure) on grammaticality judgements (*Acceptance)*

The effect of *Composite* (Bokmål engagement/exposure) on the difference in grammaticality judgement (*Acceptance*) between non-/agreement conditions was evaluated using a pairwise comparison test within each group. The test reveals that the influence of *Composite* on *Acceptance* levels between non-/agreement conditions was significant for Northern Norwegian participants – both for gender (estimate = 0.702, SE = 0.178, z.ratio = 3.934, p = 0.0001) and for number (estimate = 0.738, SE = 0.199, z.ratio = 3.714, p = 0.0002) – but not for Sunnmørsk participants (*gender*: estimate = 0.264, SE = 0.192, z.ratio = 1.373, p = 0.1696; *number*:

estimate = −0.064, SE = 0.194, z.ratio = −0.327, p = 0.7433). **Essentially, these results for number agreement among Northen Norwegian participants illustrate that dialect–orthography misalignment effects can be mitigated by engagement/exposure to the standard variety. That is, Northern Norwegians at the right end of the *Composite* scale show responses which clearly distinguish Bokmål number non-agreement, resembling Sunnmørsk participants who have no dialect–orthography misalignment in this condition.**

Preliminary results suggest EEG measures do not display significant influence of Bokmål experience

Though we see effects of participants' engagement with/exposure to Bokmål in off-line, behavioural measures, their brain responses (in our preliminary results) do not show the same pattern[4]

- ☞ no significant effect of Bokmål experience (*Composite*) on amplitude differences between non-/agreement trials in number agreement (for either group)
- but Northern Norwegian participants do display a (unexpected) significant decrease in amplitude differences for gender agreement with increasing *Composite* (Bokmål engagement/ex)
    - in other words, as participants' engagement with/exposure to Bokmål increases, they display more attenuated P6 effects (not expected)

Cross-dialectal influence in on-line (EEG) and off-line (behavioural) measures: These preliminary results reveal potentially important differences in on-line and off-line effects of bilectal experience on bilectal processing

- ☞ bilectals' brain processing and behavioural judgements do not always align
    - but on this point, we have much more investigation to do...*to be continued*

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[4]Pairwise comparison tests within each group reveal that the influence of *Composite* on *Amplitude* levels between non-/agreement conditions is non-significant for the *number* condition for both Northern Norwegian participants (estimate = 0.176, SE = 0.108, z.ratio = 1.625, p = 0.104) and Sunnmørsk participants (estimate = 0.025, SE = 0.154, z.ratio = 0.165, p = 0.869). Likewise, *Composite* has no significant effect on Sunnmørsk gender agreement processing patterns (estimate = 0.010, SE = 0.154, z.ratio = 0.065, p = 0.948), but significantly decreases amplitude differences for Northern Norwegian participants (estimate = 0.501, SE = 0.108, z.ratio = 4.637, p < 0.0001).
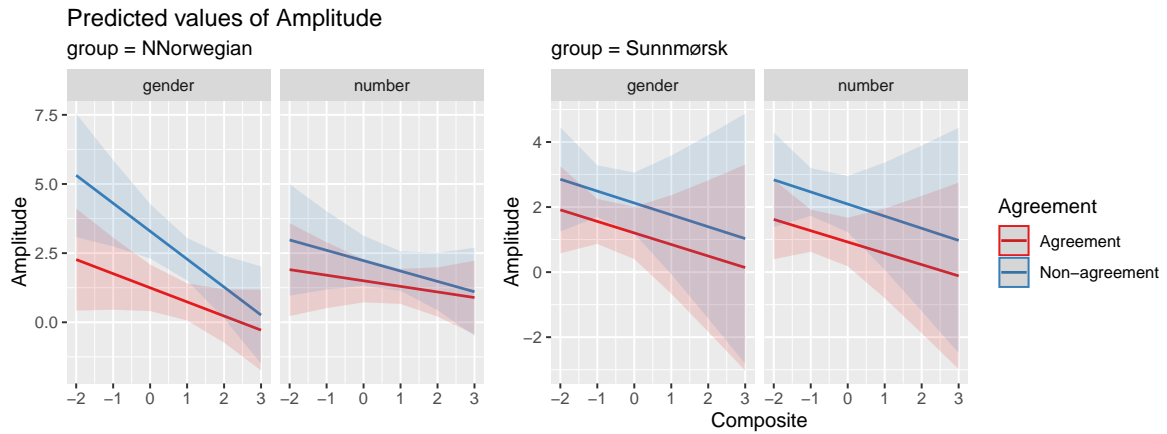
Figure 10: Predicted values illustrating lack of significant influence of *Composite* (Bokmål engagement/exposure) on brain responses to non-/Agreement trials in gender and number conditions by group

4 Summary

In summary, these studies (on-going) suggest that bilectalism is a proper sub-case of bilingualism

- Non-northern Norwegians' brain responses to Northern Norwegian dialects vary according to their exposure to Northern Norwegian dialects (experiment 1)

  ☞ processing of dialect-specific features is modulated by exposure to that dialect (something resembling L2-LEARNING)

- Northern Norwegians show P600 effects of predicate number *agreement* when they read Northern Norwegian dialect writing but *non-agreement* when reading Bokmål

  ☞ bilectals adjust their processing strategies according to the linguistic input (DISTINCT BILECTAL GRAMMATICAL REPRESENTATIONS)

- We observe an attenuating effect where the linguistic varieties are grammatically misaligned

  ☞ misaligned grammatical features interact in bilectal processing (CROSS-DIALECTAL INFLUENCE ON BILECTAL PROCESSING)

- Northern Norwegian participants' grammaticality judgments are modulated by Bokmål engagement/exposure

  ☞ Effects of grammatical alignment (at least behaviourally) are modulated by bilectal experience (CROSS-DIALECTAL INFLUENCE VARIES BY BILECTAL EXPERIENCE)

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