Heliyon 10 (2024) e24896

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Überachiever or *Developerin*: Eye movements during the processing of translingual hybrid noun-formations

Nina Dumrukcic [a,*], Sandra Kotzor [b,c]

[a] *University of Cologne, Germany*
[b] *LMU Munich, Germany*
[c] *University of Oxford, UK*

ARTICLE INFO

Keywords:
Hybrid words
Noun-formation
Bilingualism
Eye-tracking
Lexical processing

ABSTRACT

This eye tracking experiment tests how the brain recognizes and processes hybrid German-English word-formations and how this process compares to monolingual items. Thirty bilingual German-English adults from the Oxford area (23 females; mean age = 28.0, SD = 9.3) who were familiar with the meaning and underlying structure of the individual components had no comprehension difficulties. After fitting linear mixed effects models (95 % CI), the results showed an effect of word length and previous exposure to hybrid forms on processing times, indicated by longer fixation times and increased regressions, particularly in later stages of lexical processing. This indicates that bilingual readers have no trouble recognizing hybrid words, but may have difficulty with semantic and syntactic integration due to lack of exposure.

1. Introduction

Globalisation and the dominance of English as a lingua franca have led to an increase in the number of hybrid word-forms in numerous languages [1]. This process of combining linguistic elements from different languages, known as hybridization, is a consequence of multilingualism which enables the speaker to have access to a broader array of phonological, lexical, and syntactic features [2]. In this paper, we use eye tracking to investigate how bilingual German-English speakers process hybrid forms.

As a rich source of data for reading comprehension [3–5], eye-movement measures have previously been used to study determiner-noun or auxiliary-verb switches Valdés Kroff et al. [6] or how compounds are processed [7–9]. There is, however, a lack of research on whether complex hybrid words are processed in a similar manner. While Wu and Xi [10] conducted an experiment on procession acronyms, words, and phrases with features from multiple languages, their sample size consisting of 8 participants was low. This, combined with the diverse stimulus set, did not allow firm conclusions to be drawn.

Difficulties in processing hybrid items which combine linguistic features such as morphemes from multiples languages or two nouns from English and German into a compound indicates that this type of multilingual discourse might result in a language-mixing cost. Yet, we know that such items are produced by multilingual speakers and understood by their interlocutors. Although little research has been done on comprehension-based language-mixing costs [11], it is suggested that in dense language switching contexts which allow the speakers to shuttle between languages, there are little to no control processes necessary [12]. Studies on voluntary, as opposed to cued language switching where bilinguals could freely choose which language to produce showed a mixing benefit indicating that

* Corresponding author.
E-mail address: nina.dumrukcic@uni-koeln.de (N. Dumrukcic).

https://doi.org/10.1016/j.heliyon.2024.e24896
Received 5 April 2023; Received in revised form 5 January 2024; Accepted 16 January 2024
Available online 30 January 2024
2405-8440/Â© 2024 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

utilizing two languages resulted in faster response times than one [13,14] and revealed that language-switch costs during bilingual language comprehension do not always occur [15]. However, this study uses a different paradigm, where bilinguals are exposed to carrier sentences in both languages; therefore, both German and English remain active throughout the task once they encounter the hybrid items.

If both languages are activated during the processing of hybrid words, this raises the questions of whether there is a unitary system containing all the linguistic features from multiple languages that are used to produce and comprehend hybrid word. Kecskes finds that "we have one conceptual system that may operate more than one language" [16] and "it is not languages that compete for selection, but words" (emphasis by author) [16]. Otheguy, García, & Reid argue that "the mental grammars of bilinguals are structured but unitary collections of features, and the practices of bilinguals are acts of feature selection, not of grammar switch" [17]. Furthermore, García & Otheguy believe that mental grammars "consist of large and complex arrays of disaggregated structural features (phonetic, phonological, morphological, and semantic) that do not belong to or reside inside of the speaker's two or more languages by virtue of inherently differentiated linguistic membership" [18]. Multilinguals therefore create hybrid words by combining features from their mental lexicon.

The aim was to measure whether processing hybrid items incurs cognitive costs, which in a reading task refers to longer fixations and more regressions [19–21]. Visual word processing is also affected by word length [22–26], lexical entrenchment [19], predictability [27], and frequency [28–34], therefore, factors were also controlled for in the stimuli.

Our predictions were as follows:

- Latencies in the reading performance of hybrid word-formations depend on the readers' previous exposure to hybrid words.
- The degree of lexicalisation may affect processing times which raises the question of whether highly lexicalized items are still considered hybrid forms.
- The readers might initially recognize the hybrid words but may have more difficulty integrating them in the broader sentence context which would be reflected in later stages of processing.

Other factors which may impact reading comprehension, such as whether participants reported being German- or English-dominant, were also taken into consideration.

2. Hybrid noun-formations

Coats [35] measured the salience of new verbal anglicisms such as *relatieren* 'relate' in a corpus of German-language tweets and found that not only are these new words orthographically integrated into the German lexicon but their frequency is also on the rise. Jahn described the process as the "Denglishisation" [36] of the German language, where English vocabulary, syntactic structure, punctuation, and grammar are used to create hybrid forms combining features from both languages. Comparative corpus analyses of English-German hybrid formations which include blended compounds, such as *Krafttraining* 'strength training', showed that lexical hybridization occurs both in spoken corpora and text corpora [37]. Structural analyses of hybrids on the lexicological level in a German IT corpus showed that most hybrid items comprised two constituents e.g., *Schadsoftware* 'malware' [2].

Language learners first learn individual words and word forms but gradually coin new words and word forms according to abstract schemas [38]. Bilingual speakers with very high levels of proficiency combine morphemes from different languages into one coherent meaningful unit. A hybrid item may, for instance, contain the English plural possessive apostrophe in a German word where the orthography dictates there would be no apostrophe, i.e., *Mutti's* 'mummy's' found in Louise Rennison's novel [39]. The hybrid item *U-Bahns* 'subways' is categorised as a noun with a German stem and an English inflectional suffix. The word *Developerin* 'female developer' has an English base, *developer*, to which the German derivational suffix *-in* is added. Hybrid compounds consist of one German and one English morpheme/word such as *Lederbag* 'leather bag'. The English word *bag* is the head, and the German word *Leder* 'leather' is the modifier, specifying the type of bag in an A + B is a type of B construction.

3. Method

3.1. Participants

Thirty bilingual German-English adults from the Oxford area (23 females; mean age = 28.0, SD = 9.3) took part in the experiment and their data was anonymised. Due to the difficulty in finding balanced bilinguals with similar levels of proficiency in German and English, there was a wider age range. All had high levels of education and were university students or graduates, normal or corrected-to-normal vision, and no language, neurological or hearing disorders. Each participant completed a language assessment survey to determine their language biography and proficiency prior to the eye tracking experiment. The language assessment questionnaire (Appendix A) is a newly developed survey based on several existing bilingualism questionnaires and personal experience with bilingual data collection. The questions were divided into several categories. The participants were asked to state their age, nationality, and mother tongue. The first section of the questionnaire focused on *Early Language Development*. It was adapted from the University of Ottawa Language Background Questionnaire Extended Version for English [40], however, some of the questions were slightly changed, such as the infancy cut-off age being adjusted to 3 years old, instead of 24 months, to be consistent with the US Department of Health and Human Services definition of "bilingual infants," (i.e., children younger than 36 months of age) [41]. The Language Experience and Proficiency Questionnaire LEAP-Q [42] was also utilized. The participants were asked to provide information

regarding their parent/caregiver, such as their nationality, place of birth, places of residence, native language and other languages, how much time per week they spent with the participant in infancy, and what language(s) they used to communicate. Then the participant was asked to list all the named languages they were exposed to in infancy, the approximate percentage of the time they heard that language on a weekly basis, and whether they used the language as an adult.

The subsequent section was on *Current Language Proficiency*. The participants were asked to specify the named languages they are proficient in, and the circumstances under which they use each respective language e.g., at home when interacting with family, a primary language of instruction in school, for professional purposes and with colleagues, for daily activities in the community such as buying groceries, conversing with neighbours etc. They were also asked whether they had taken any standardised tests for language proficiency such as TOEFL or IELTS for English as a foreign language, and Test DaF or DSH for German as a foreign language, and to state their score. The 'Circumstances of language learning' sub-section of the questionnaire was adapted from the CILT [43] language biography questionnaire, used by the Council of Europe [44]. The latter part asked the participants to state whether they had taken any standardised foreign language tests in German or in English. These questions focused on the social context and frequency when it comes to using the languages in order to assess proficiency in the present day.

The final section dealt with *Self-Assessment of Language Proficiency*. Using the Self-Assessment Grid by the Common European Framework of Reference, the participants provided scores for their language level skills in listening, reading, spoken interaction, spoken production, and writing in English, and in German [44]. They were asked whether they consider German or English to be their more dominant language. The final task of the questionnaire was an open-ended response where the participants had the opportunity to write about their language learning experience in English or German.

All participants were also interviewed after the experiment to discuss potential difficulties in reading comprehension.

1) How did you find the experiment?
2) Did you struggle to understand any of the words?
3) If yes, which one(s)?
4) Have you come across texts/social media posts/other forms of media where you encountered a mix of German and English within the same communicative event?
5) If you can remember any examples, please provide them.

Their responses were analysed qualitatively and grouped based on whether they had issues with self-reported reading comprehension. The analysis was not based on a numerical scale, but rather open-ended responses which were clustered. Individual demographic information for the participants is available in Appendix A. All participants gave informed consent and were compensated accordingly for their time.

3.2. Stimuli

Target items were divided into three conditions: hybrid noun-formations, monolingual German, and monolingual English counterparts (see Table 1 for examples and Appendix C for full list). Items were divided into 'long' and 'short' words, depending on the median and mode number of characters (11). Frequency was expressed as occurrences in corpora[1] per million words [45] and the means of normalised frequencies in two German and two English corpora were calculated. Based on the median values of monolingual English items in English corpora (0.3643), monolingual German items in German corpora (0.1181), translingual items in English corpora (0), and translingual items in German corpora (0.0005), the items were categorised as 'high' or 'low' frequency. The target items were incorporated into sentences taken from corpus concordances and adjusted according to eye tracking criteria. The base language of the sentences was German in half of the sentences and English in the other half.

To avoid repetition effects, stimuli across the experimental conditions were counterbalanced across three separate lists according to a within-subjects design, such that each participant saw thirty critical sentences but never the monolingual counterparts of the hybrid items. Target words were presented in similar positions in the respective sentences [45] to prevent wrap up effects [4,28,49]. The target items were not placed after particularly difficult, long, or uncommon words to avoid spillover effects [50].

3.3. Procedure

The experiment was designed and deployed using SR Research Experiment Builder software [51]. The equipment consisted of a desktop-mounted EyeLink 1000 Plus (SR Research™) connected to a host PC and 21-inch monitor. The viewing was binocular, but eye movements were tracked monocularly in head-stabilised mode. The experiment began with three practice trials and participants completed a nine-point calibration and validation prior to the experiment block. Each trial began with a drift correction, during which the participant had to fixate on a point before the trial proceeded. Participants' eye movements were recorded from the onset of the visual stimuli until the keyboard click when they finished reading the sentence, at a sampling rate of 1000 Hz. Fixations and saccades were extracted using the default system settings of the eye-tracker.

After the completion of the experiment, the participants were debriefed and completed a questionnaire about comprehension

[1] The following corpora were used: British National Corpus [46], English Web 2013 Corpus enTenTen [47], The Mannheim German Reference Corpus (DeReKo) [48] (Institute for the German Language, 2019), and German Web 2013 Corpus deTenTen [47].

Table 1
German-English hybrid stimuli.

Type	Form	Example	Sentence example	No. of items
Punctuation	N (LX) + '(LY) + Suffix (LY)	[$_{N}$ [$_{Ger\ N}$ **Mutti**] [$_{Eng\ possessive\ case}$ **–'s**]]	He is a man with a voice as soft as *Mutti's* silk blouses, but yesterday he shouted very loudly. 'He is a man with a voice as soft as *Mummy's* silk blouses, but yesterday he shouted very loudly.'	2
Compound	N (LX) + N (LY)	[$_{N}$ [$_{Ger\ N}$ **Leder**] [$_{Eng\ N}$ **bag**]]	Abends machen Sie einfach den Riemen ab und schlendern mit Ihrer coolen *Lederbag* durch die Stadt. 'In the evening, simply take the belt off and take your cool leather bag, for a stroll around the city.'	16
Compound	N (LY) + N (LX)	[$_{N}$ [$_{Eng\ N}$ **hater**] [$_{Ger\ N}$ **Kommentar**]]	Ab und zu ecome ich zwar auch den ein oder anderen *Haterkommentar*, aber die ziehen mich nicht runter. 'Although I also get the occasional hate comment here and there, they don't drag me down.'	8
Inflectional Suffixation	N (LX) + Infl. Suffix (LY)	[$_{N}$ [$_{Ger\ N}$ **U-Bahn**] [$_{Eng\ plural}$ **-s**]]	Incidents like these kept recurring in Berlin, along with music on the *U-Bahns* and at the stations. 'Incidents like these kept recurring in Berlin, along with music on the subways and at the stations.'	3
Derivational Suffixation	N (LX) + Deriv. Suffix (LY)	[$_{N}$ [$_{Ger\ N}$ [$_{Eng\ N}$ **developer**]] [$_{Ger\ suffix}$ **-in**]]	In der Zeitung erscheint zurzeit ein Artikel mit der *Developerin* einer neuen Plattform für Köchinnen. 'In the newspaper, there is currently an article with the developer for a new platform for cooks.'	1

difficulties, followed by a discussion on previous exposure and production of hybrid multilingual words. The experiment was approved by the Central University Research Ethics Committee (695,481).

4. Results

The data was first visually inspected using the SR Research Data Viewer [51] temporal graph view to check for track loss. Blinks and fixations shorter than 80 ms were merged and those longer than 1000 ms excluded [52,53] using the automatic removal option.

Linear mixed effects models were fitted in RStudio (Version 3.6.2) [54] using the *lme4* package (Version 1.1–23) [55] and plotted using the *sjPlot* package (Version 2.8.9) [56] for each eye tracking measure. Due to common skewness in latency measures, the data required a log or square root transformation [3]. The models were assessed for goodness of fit using the anova function and compared using Akaike Information Criterion (AIC) to determine which model fits the data best. A backward model selection approach was used for each separate measure. The hybrid noun-formations containing both German and English features were coded as translingual, and the items which contained featurs from either only German or only English were coded as monolingual.

The fixed effect factors were *Hybrid Status*, *Word Length*, *Frequency*, and *Language Dominance*. The dependent variables were the measures commonly used for determining reading performance: *First Fixation Duration*, *Gaze Duration*, *Total Fixation Time*, and *Selective Regression Path Duration* [3,50]). The subjects and items were included as random effects. Confidence intervals were set at 95 % and *p*-values were calculated using the Wald approximation [57]. The model means and confidence intervals were back-transformed from log transformed or square root values for all the measurements and a relevel function was used to set translingual items as a reference for comparison.

First, the mean durations for all four measurements were considered across all conditions (Fig. 1). This visualisation depicts differences among conditions, with the translingual items showing the longest mean durations, particularly for later stages of lexical processing, such as Selective Regression Path and Total Fixation Time.

4.1. First fixation duration

For First Fixation Duration, a pairwise comparison of monolingual English and monolingual German items showed no significant difference ($W = 40{,}813$, $p = 0.9769$). However, average First Fixation Duration (in ms) was longer for translingual items ($M = 231$, $SD = 96$) than for monolingual English ($M = 217$, $SD = 85$) and monolingual German ($M = 214$, $SD = 77$) items.

The linear mixed effects model was kept maximal [58] and the inclusion of *Language Dominance* as a fixed effect did not improve the model fit ($\chi^2(10) = 14.25$, $p = 0.16$). The model including *Hybrid Status*, *Frequency*, and *Word Length Type* as well as their interactions as fixed effects had a lower AIC (667.89) compared to the model including *Language Dominance* ($AIC = 673.63$). Although *Frequency* and *Word Length* follow a similar pattern for monolingual English and monolingual German items, for translingual items, the shorter words actually had longer First Fixation Duration than longer words (see Fig. 2). Within this model, none of the predictors as a main effect nor the interactions had a significant impact on the dependent variable (see Table 2).

4.2. Gaze duration

Monolingual German and monolingual English items did not have significant differences in Gaze Duration ($W = 38{,}295$, $p = 0.212$).

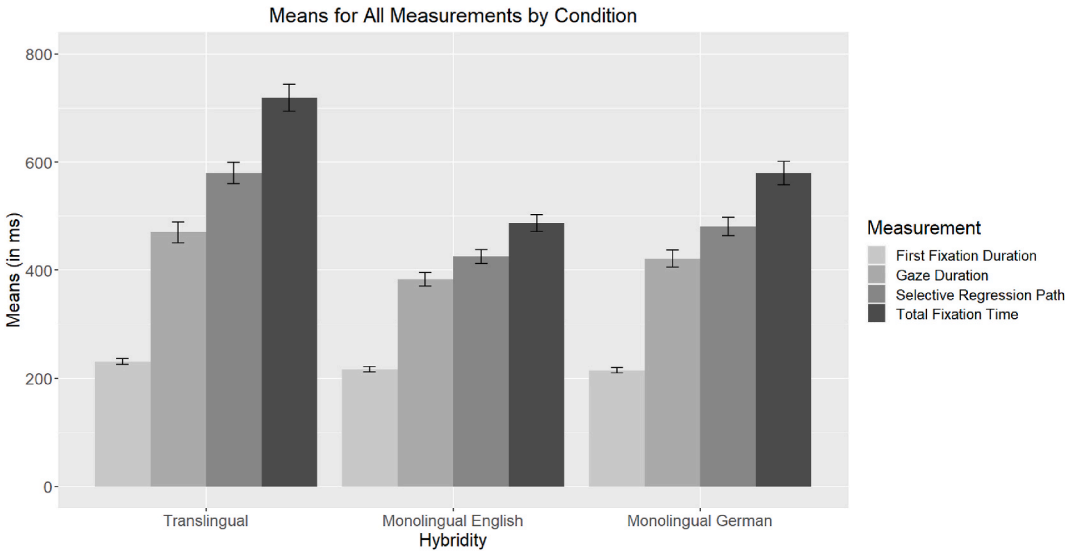

Fig. 1. Means for all measurements across conditions.

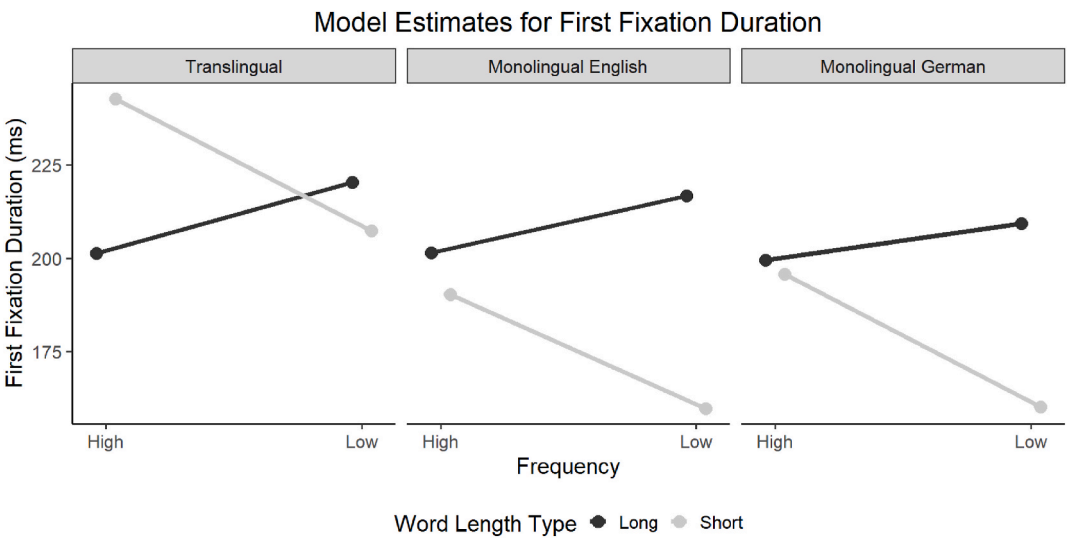

Fig. 2. Model estimates for the first fixation duration of target items.

Gaze Duration was longer for translingual items ($M = 470$, $SD = 331$) compared to both monolingual English ($M = 382$, $SD = 211$) and monolingual German ($M = 421$, $SD = 262$) items. The lmer model which converged included *Hybrid Status*Word Length*Frequency* and *Subject* and *Item* factors as random slopes. The exclusion of *Language Dominance* as a fixed effect in a stepwise approach showed an improvement in model fit ($\chi^2(10) = 24.36$, $p < 0.007$). The monolingual English and German items show a similar pattern with longer Gaze Duration for longer words, whereas the translingual items do not (Fig. 3).

Within this model, none of the main effects nor the interactions were statistically significant as shown in Table 3.

4.3. Total fixation time

There is a significant difference between monolingual English and monolingual German items among the monolingual items ($W = 35{,}066$, $p = 0.004$). The monolingual English items had the shortest sum of fixations including regressions ($M = 487$, $SD = 263$) followed by monolingual German ($M = 580$, $SD = 365$), while the translingual items had the longest Total Fixation Time ($M = 719$, $SD = 428$). The linear mixed model was fitted to predict Total Fixation Time with *Hybrid Status*Word Length*Frequency* and *Subject* and *Item* random effects where the slopes were allowed to vary. Adding *Language Dominance* as a main effect did not lead to a difference in model fit ($\chi 2(10) = 15.27$, $p = 0.122$).

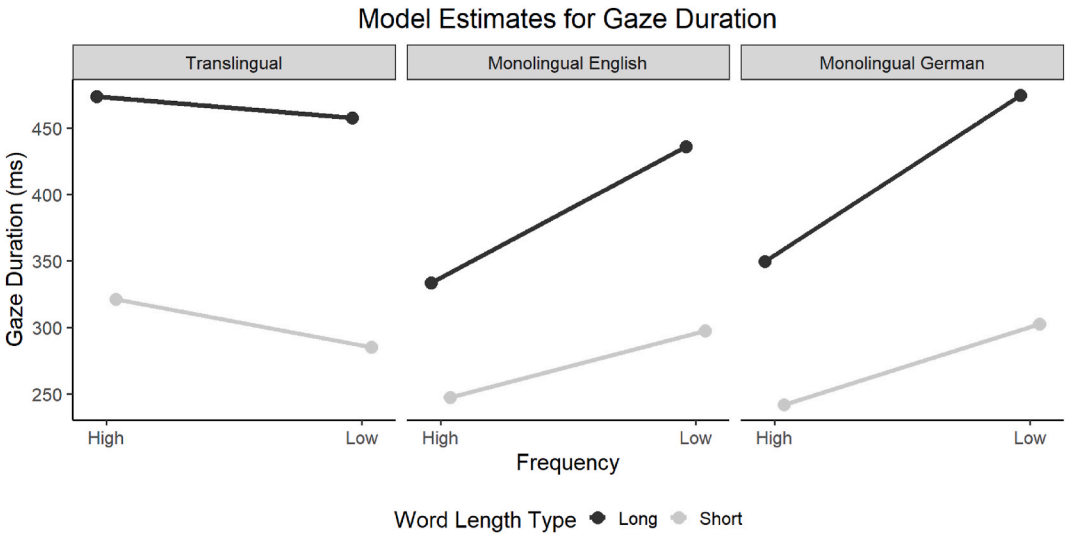

Fig. 3. Model estimates for the gaze duration of target items.

Results showed longer Total Fixation Time for translingual words compared to monolingual English items ($\beta = -0.44$, 95 % CI [−0.77, −0.11], $t(845) = -2.64$, $p = 0.008$) and monolingual German items ($\beta = -0.35$, 95 % CI [−0.68, −0.02], $t(845) = -2.05$, $p = 0.040$) as portrayed in Fig. 4. *Word Length* as a main effect proved to be statistically significant with words containing fewer characters having a shorter Total Fixation Time ($\beta = -0.67$, 95 % CI [−1.20, −0.13], $t(845) = -2.46$, $p = 0.014$). Frequency as a main effect and all interactions were non-significant (see Table 4).

4.4. Selective regression path duration

Selective Regression Path Duration differed between the two types of monolingual items ($W = 36{,}650$, $p = 0.03731$). The comparison of means showed that Selective Regression Path Duration was longer for translingual items ($M = 580$, $SD = 336$) than for monolingual German ($M = 481$, $SD = 258$) and monolingual English items ($M = 425$, $SD = 213$). The model with the best fit included *Hybrid Status*Word Length*Frequency* as fixed effects. Excluding *Language Dominance* significantly improved the model fit ($\chi^2(10) = 28.69$, $p < 0.001$).

Coefficients representing the main effect of *Hybrid Status* were significantly shorter for both monolingual English ($\beta = -4.80$, 95 % CI [−8.16, −1.44], $t(845) = -2.80$, $p = 0.005$) and monolingual German ($\beta = -4.11$, 95 % CI [−7.50, −0.71], $t(845) = -2.37$, $p = 0.018$) items compared to the translingual items. Shorter words had significantly shorter durations than longer words ($\beta = -7.42$, 95 % CI [−12.87, −1.96], $t(845) = -2.67$, $p = 0.008$) as shown in Fig. 5. *Frequency* as a main effect and all the interaction were statistically

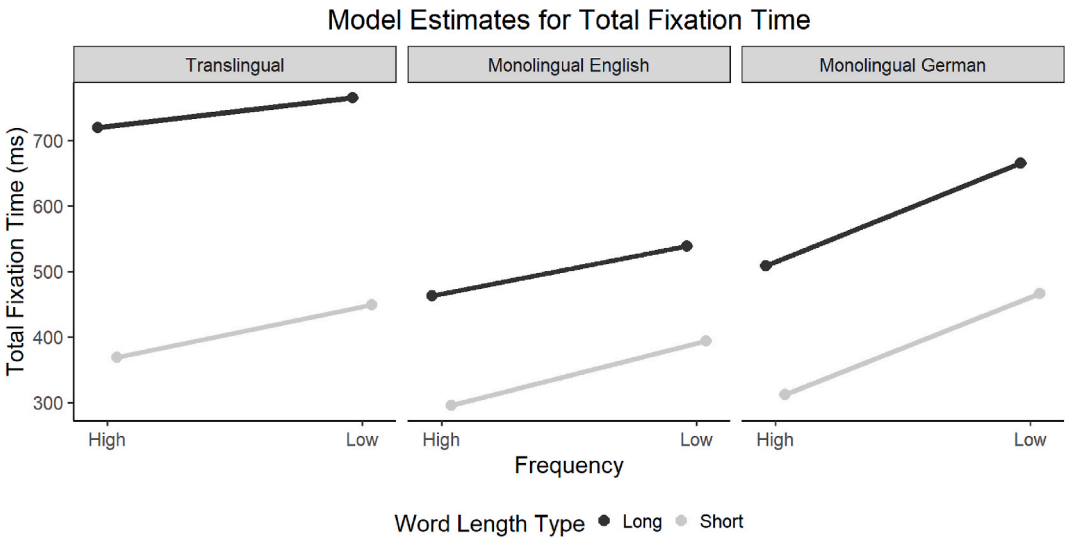

Fig. 4. Model estimates for the total fixation time of the target items.

non-significant (see Table 5).

The full output of all models can be viewed in Appendix B.

5. Discussion and main findings

By looking at the four most commonly used eye tracking measurements which indicate cognitive cost [3], this study aimed to determine how bilingual speakers process hybrid bimorphemic words in comparison to their monolingual counterparts.

For earlier measurements, such as First Fixation Duration, which reflect word recognition, the shorter hybrid words showed longer fixation durations for higher frequency items. This is rather unexpected considering fewer characters usually result in shorter fixation as shown with the monolingual items in later stages of processing. For the longer words, the less salient items had longer fixations which is consistent with the aforementioned eye tracking literature. This indicates that frequency and word length may not necessarily determine how quickly a hybrid item is recognized.

Gaze Duration showed more predictable findings regarding *Word Length* with longer words having more fixations. However, for the hybrid items, the high frequency items seemed to be processed slightly longer which is contrary to findings in academic literature, although this is likely due to the difficulty of categorising hybrid items in terms of high or low frequency and the number of occurrences in corpora might not reflect item familiarity of individual participants.

The results showed a significant latency difference in later stages of lexical processing for hybrid items compared to their monolingual counterparts. Total Fixation Time and Selective Regression Path Duration, which are linked to sentence integration [25, 50], follow a more expected pattern that is consistent with eye tracking studies showing shorter words have faster processing times. This aligns with our predictions that hybrid items might require more cognitive effort to be integrated into the sentence. An interesting finding is that there were differences in processing even between monolingual German and monolingual English items as demonstrated by the former having longer Total Fixation Time. This further shows how difficult it is to maintain accuracy in translation when finding the closest monolingual counterparts to the hybrid words whilst controlling for other item factors that are known to impact eye movements.

Determining frequency for hybrid items was very challenging since they are generally scarce in corpora in comparison with monolingual items. A future point of study is determining the threshold for words consisting of German and English morphemes which have become lexicalized to the point that they are no longer idiosyncratic hybrid forms (e.g., *Powerfrau* 'power woman') but considered to be a part of the lexicon even by non-active bilingual speakers. Moreover, although all of the stimuli were produced by multilingual speakers, some of their monolingual counterparts were very infrequently used. Replication of the study would require re-evaluation of the stimuli with a greater number of stimuli items.

Even though all participants were very highly proficient in both German and English, their previous exposure to hybrid items differed, with 6 % claiming they did not usually encounter translingual words (Appendix A). For all four eye tracking measurements, self-reported language dominance did not significantly affect results.

Previous evidence suggests there is no language switch cost for bilingual speakers, who often utilize multiple languages when communicating [59–64]. Lexical frequency also plays a role in the structure of language mixing [65,66]. Limitations of the study include the difficulty in distinguishing between whether the participants who had previous exposure to the hybrid items had shorter fixation times, but this would have entailed showing them the stimuli beforehand which would have resulted in bias. Further shortcomings of the study include a lack of power analysis prior to the experiment due to limited resources and funding. New word-formations that consist of morphemes from German and English are highly productive because they have a similar underlying structure to monolingual items and are setting the pattern for novel words. The evidence in this study highlights how latencies in reading hybrid words is not merely due to the hybrid nature of the items themselves, but rather due to a multitude of other factors such as word length, previous experience with comprehension and production of hybrid words, and familiarity with individual morphemes of the hybrid item.

This means that bilingual language users are able to utilize all the linguistic features from multiple languages that they have access to and, provided they understand individual components of a word, determine meaning of hybrid words. Bilinguals can rapidly adapt to processing hybrid items which they may not have necessarily encountered before by accessing the individual semantic components of a hybrid word in their mental lexicon. However, lack of previous exposure to hybrid words leads to increased mental effort in comprehending such words as shown by latencies in the eye tracking measures, particularly for later stages of processing. The more often a bilingual individual encounters hybrid words, the faster and more effortless their processing should be as they recognize these words as a natural part of multilingual discourse. The follow-up discussions with participants also support these findings, since most participants claimed they produce hybrid complex words themselves and had no difficulty understanding them. Several participants stated in the questionnaire they found the hybrid words 'unusual' but could comprehend them, nonetheless. Hybrid words that are more entrenched in German are processed in a similar manner to monolingual items because there is an increased likelihood that the participants have had previous exposure to such items.

From a cognitive perspective, if there is only one unitary system, the only reason individuals recognize a linguistic feature such as a phoneme, morpheme or structural element as belonging to a glottonym is because of social norms and they are stored cognitively with those social labels which allows the bilingual person to know the social situation in which those features can be utilized. Despite social stigma and policy, as shown by examples from the surveys and eye tracking experiment in this study, bilingual speakers can and do produce and process word-formations using their entire linguistic repertoire regardless of which social label a feature may carry. The reason behind the latency in the translingual items is not necessarily because they have features from two glottonyms that are separated from a social perspective, but because these are word-formations the reader has not come across as often.

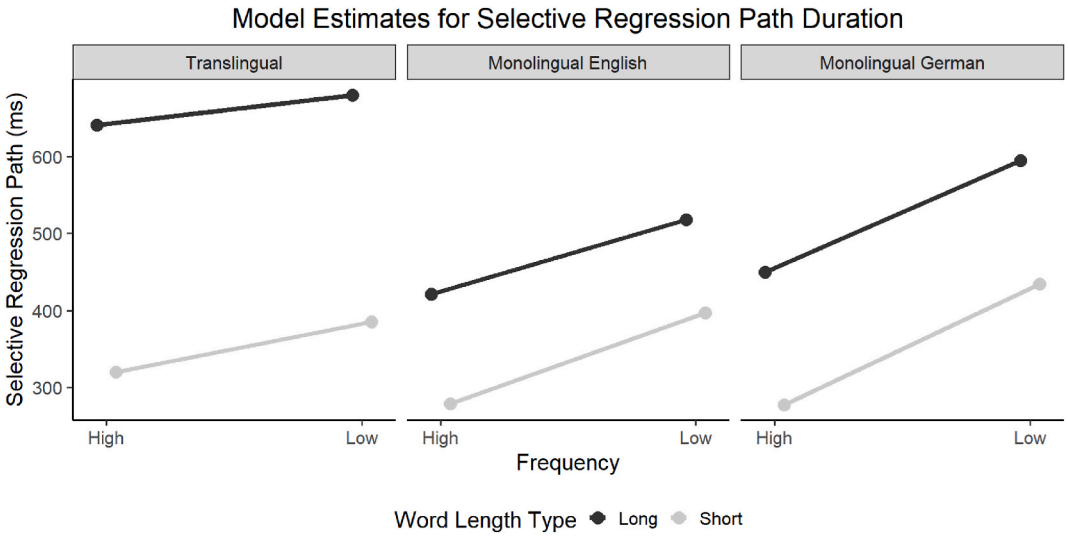

Fig. 5. Model estimates for the selective regression path duration of the target items.

More work is needed on switch cost within individual words that combine for instance English stems with German affixation both for loan words e.g. *getriggert* (triggered) and hybrid words e.g. *gecringed* (cringed). The follow-up study is currently underway and will explore in further detail bilingual lexical activation of hybrid words. Providing evidence that bilinguals are able to process hybrid words adequately and without confusion or difficulty challenges social norms, perception, and policy on utilizing multiple languages for meaning-making purposes.

CRediT authorship contribution statement

Nina Dumrukcic: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Sandra Kotzor:** Writing – original draft, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:Dr. Nina Dumrukcic reports financial support was provided by Baden-Württemberg-STIPENDIUM.

Acknowledgements

We would like to thank Professor Aditi Lahiri (University of Oxford) for her time and guidance and for the experiment being run under the MORPHON project which was approved by the European Union's Horizon 2020 Research and Innovation Programme (Grant agreement number: 695481). We want to thank Dr Nadja Althaus (University of East Anglia) for her assistance with the eye-tracking statistical analysis and constructive comments. We would also like to thank Professor Beatrix Busse (University of Cologne) for her support with stimuli selection. This work was supported by the Baden-Württemberg STIPENDIUM.

Appendix A

Language assessment survey responses

Participant Number	Self-Reported Dominant Language	Age	Nationality	Self-Reported Mother Tongue	Early language development – exposure to German/English before the age of 3	Current exposure to German and English	Level of Competence in English according to CEFR Framework	Level of Competence in German according to CEFR Framework	Previous exposure to hybrid German-English texts
1	English	51	British	English	English - high	German - high	native	C2	YES

(*continued on next page*)

(*continued*)

Participant Number	Self-Reported Dominant Language	Age	Nationality	Self-Reported Mother Tongue	Early language development – exposure to German/English before the age of 3	Current exposure to German and English	Level of Competence in English according to CEFR Framework	Level of Competence in German according to CEFR Framework	Previous exposure to hybrid German-English texts
2	German	38	German	German	German - high	German – high English - high	C1/C2	native	YES
3	English	25	British	English	English – high German - low	German – high English - moderate	native	B2	YES
4	German	20	German	German	German – high English - low	English – high German - moderate	C2	native	YES
5	English	22	British	English	English - high	German – high English - moderate	native	C1/C2	YES
6	German	36	German	German/ Mandarin	/(Mandarin Chinese; German and English exposure after 3)	German – high English - high	C2	native	YES
7	English	20	German	German	German – high English - high	German – high English - high	native	C1/C2	YES
8	German	45	German	German	German - high	English - high	C2	native	YES
9	English	19	British	English	English - high	English – high German - high	native	C1/C2	YES
10	German	50	German	German	German - high	German – high English - high	C2	native	YES
11	English	26	British/ Swiss	English	English – high German - low	English – high German - high	native	C1/C2	YES
12	German	20	Swiss/ German	German	German - high	German – high English - high	C1/C2	native	YES
13	English	19	British/ German	English	English – high German - moderate	English – high German - high	native	C2	YES
14	German	19	German	German	German - high	German – high English - high	C1/C2	native	NOT A LOT
15	English	21	British/ German	English	German – high English - low	German – high English - moderate	native	C1/C2	YES
16	German	31	German	German	German - high	English - high	C1	native	YES
17	English	21	British	English	English - high	English – high German - moderate	native	C1	YES
18	German	19	German	German	German – high English - low	English – high German - moderate	C2	native	YES

(*continued on next page*)

(*continued*)

Participant Number	Self-Reported Dominant Language	Age	Nationality	Self-Reported Mother Tongue	Early language development – exposure to German/English before the age of 3	Current exposure to German and English	Level of Competence in English according to CEFR Framework	Level of Competence in German according to CEFR Framework	Previous exposure to hybrid German-English texts
19	English	21	British	English	English - high	German – high English - high	native	C1	YES
20	German	30	German	German	German - high	German – high English - high	C1/C2	native	YES
21	English	31	German	German	German - high	English - high	C2	native	YES
22	German	31	German	German	German - high	German – high English - high	C2	native	YES
23	English	29	German/ American	English	English – high German - moderate	German – high English - high	native	C2	YES
24	German	24	German	German	German - high	English – high German - high	C2	native	YES
25	English	25	German/ British	German	German - high	English – high German -moderate	C2	native	NOT A LOT
26	German	24	German	German	German - high	German – high English - high	C1/C2	native	YES
27	English	28	German/ American	German	German – high English - low	English – high German - low	C2	native	YES
28	German	44	German/ British	German	German - high	German – high English - high	C2	native	YES
29	English	27	British/ Spanish	English	English - high	German - high	native	C1/C2	YES
30	German	19	German	German/	German – high English - low	English – high German - moderate	C2	native	YES

Appendix B

Table 2
Results of First Fixation Duration

	log(FIRST_FIXATION_DURATION)				
Fixed Effects	*β*	*SE*	*95 % CI*	*t*	*p*
(Intercept)	5.31	0.08	[5.14, 5.47]	63.01	**<0.001**
HYBRID STATUS [Monolingual English]	0.00	0.09	[-0.17, 0.17]	0.00	0.998
HYBRID STATUS [Monolingual German]	−0.01	0.09	[-0.19, 0.17]	−0.10	0.919
WORD LENGTH TYPE [Short]	0.19	0.15	[-0.10, 0.48]	1.27	0.203
FREQUENCY [Low]	0.09	0.09	[-0.08, 0.26]	1.02	0.306

(*continued on next page*)

Table 2 (*continued*)

	log(FIRST_FIXATION_DURATION)				
Fixed Effects	*β*	*SE*	*95 % CI*	*t*	*p*
HYBRID STATUS [Monolingual English] * WORD LENGTH TYPE [Short]	−0.24	0.16	[-0.55, 0.06]	−1.57	0.118
HYBRID STATUS [Monolingual German] * WORD LENGTH TYPE [Short]	−0.21	0.16	[-0.51, 0.10]	−1.32	0.186
HYBRID STATUS [Monolingual English] * FREQUENCY [Low]	−0.02	0.10	[-0.22, 0.19]	−0.16	0.870
HYBRID STATUS [Monolingual German] * FREQUENCY [Low]	−0.04	0.10	[-0.24, 0.16]	−0.41	0.679
WORD LENGTH TYPE [Short] * FREQUENCY [Low]	−0.25	0.15	[-0.55, 0.05]	−1.61	0.108
Random Effects					
σ^2	0.12				
$\tau_{00\ ITEM}$	0.00				
$\tau_{00\ SUBJECT}$	0.01				
ICC	0.09				
$N_{SUBJECT}$	30				
N_{ITEM}	88				
Observations	858				
Marginal R^2/Conditional R^2	0.018/0.106				

Table 3
Results of Gaze Duration

	log(GAZE_DURATION)				
Fixed Effects	*β*	*SE*	*95 % CI*	*t*	*p*
(Intercept)	6.16	0.17	[5.83, 6.49]	36.34	**<0.001**
HYBRID STATUS [Monolingual English]	−0.35	0.18	[-0.71, 0.00]	−1.95	0.051
HYBRID STATUS [Monolingual German]	−0.30	0.18	[-0.66, 0.05]	−1.67	0.095
WORD LENGTH TYPE [Short]	−0.39	0.29	[-0.97, 0.19]	−1.32	0.186
FREQUENCY [Low]	−0.04	0.18	[-0.39, 0.32]	−0.20	0.844
HYBRID STATUS [Monolingual English] * WORD LENGTH TYPE [Short]	0.09	0.31	[-0.52, 0.70]	0.29	0.772
HYBRID STATUS [Monolingual German] * WORD LENGTH TYPE [Short]	0.02	0.31	[-0.59, 0.64]	0.07	0.945
HYBRID STATUS [Monolingual English] * FREQUENCY [Low]	0.30	0.21	[-0.11, 0.72]	1.44	0.149
HYBRID STATUS [Monolingual German] * FREQUENCY [Low]	0.34	0.21	[-0.07, 0.75]	1.65	0.100
WORD LENGTH TYPE [Short] * FREQUENCY [Low]	−0.08	0.31	[-0.69, 0.52]	−0.27	0.786
Random Effects					
σ^2	0.28				
$\tau_{00\ ITEM}$	0.03				
$\tau_{00\ SUBJECT}$	0.03				
ICC	0.17				
$N_{SUBJECT}$	30				
N_{ITEM}	88				
Observations	858				
Marginal R^2/Conditional R^2	0.155/0.295				

Table 4
Results of Total Fixation Time

	log(TOTAL_FIXATION_TIME)				
Fixed Effects	*β*	*SE*	*95 % CI*	*t*	*p*
(Intercept)	6.58	0.16	[6.26, 6.89]	40.90	**<0.001**
HYBRID STATUS [Monolingual English]	−0.44	0.17	[-0.77, −0.11]	−2.64	**0.008**

(*continued on next page*)

Table 4 (*continued*)

	log(TOTAL_FIXATION_TIME)				
Fixed Effects	*β*	*SE*	*95 % CI*	*t*	*p*
HYBRID STATUS [Monolingual German]	−0.35	0.17	[-0.68, −0.02]	−2.05	**0.040**
WORD LENGTH TYPE [Short]	−0.67	0.27	[-1.20, −0.13]	−2.46	**0.014**
FREQUENCY [Low]	0.06	0.17	[-0.26, 0.39]	0.37	0.712
HYBRID STATUS [Monolingual English] * WORD LENGTH TYPE [Short]	0.22	0.29	[-0.35, 0.79]	0.76	0.446
HYBRID STATUS [Monolingual German] * WORD LENGTH TYPE [Short]	0.18	0.29	[-0.39, 0.75]	0.62	0.538
HYBRID STATUS [Monolingual English] * FREQUENCY [Low]	0.09	0.20	[-0.29, 0.47]	0.46	0.643
HYBRID STATUS [Monolingual German] * FREQUENCY [Low]	0.21	0.19	[-0.17, 0.59]	1.07	0.283
WORD LENGTH TYPE [Short] * FREQUENCY [Low]	0.13	0.29	[-0.43, 0.70]	0.47	0.638
Random Effects					
σ^2	0.20				
$\tau_{00\ ITEM}$	0.03				
$\tau_{00\ SUBJECT}$	0.06				
ICC	0.30				
$N_{SUBJECT}$	30				
N_{ITEM}	88				
Observations	858				
Marginal R^2/Conditional R^2	0.254/0.479				

Table 5
Results of Selective Regression Path Duration

	sqrt(SELECTIVE_REGRESSION_PATH)				
Fixed Effects	*β*	*SE*	*95 % CI*	*t*	*p*
(Intercept)	25.31	1.63	[22.10, 28.52]	15.48	**<0.001**
HYBRID STATUS [Monolingual English]	−4.80	1.71	[-8.16, −1.44]	−2.80	**0.005**
HYBRID STATUS [Monolingual German]	−4.11	1.73	[-7.50, −0.71]	−2.37	**0.018**
WORD LENGTH TYPE [Short]	−7.42	2.78	[-12.87, −1.96]	−2.67	**0.008**
FREQUENCY [Low]	0.76	1.70	[-2.57, 4.10]	0.45	0.653
HYBRID STATUS [Monolingual English] * WORD LENGTH TYPE [Short]	3.60	2.95	[-2.19, 9.39]	1.22	0.223
HYBRID STATUS [Monolingual German] * WORD LENGTH TYPE [Short]	2.88	2.96	[-2.92, 8.69]	0.97	0.330
HYBRID STATUS [Monolingual English] * FREQUENCY [Low]	1.48	2.00	[-2.43, 5.40]	0.74	0.457
HYBRID STATUS [Monolingual German] * FREQUENCY [Low]	2.42	1.97	[-1.44, 6.29]	1.23	0.219
WORD LENGTH TYPE [Short] * FREQUENCY [Low]	0.97	2.93	[-4.77, 6.72]	0.33	0.739
Random Effects					
σ^2	19.93				
$\tau_{00\ ITEM}$	2.83				
$\tau_{00\ SUBJECT}$	5.12				
ICC	0.29				
$N_{SUBJECT}$	30				
N_{ITEM}	88				
Observations	858				
Marginal R^2/Conditional R^2	0.270/0.478				

Appendix C
Stimuli items by condition

Translingual	German	English
Werbeshootings	Werbeaufnahmen	advertisement shootings

(*continued on next page*)

Appendix C (*continued*)

Translingual	German	English
Haterkommentar	Hasskommentar	hate comment
Danceschuhe	Tanzschuhe	dance shoes
Developerin	Entwicklerin	developer
U-Bahns	U-Bahnen	subways
Bauchworkout	Bauchtraining	abdominal workout
Fettburning	Fettverbrennung	fat burning
Tintencartridge	Tintenpatrone	ink cartridge
Chickengerichten	Hähnchengerichten	chicken dishes
Überachiever	Überflieger	overachiever
Welcomepaket	Willkommenspaket	welcome pack
Vati's	Vatis	Daddy's
Lifestil	Lebensstil	lifestyle
Biergarden	Biergarten	beer garden
Umweltaward	Umweltpreis	environmental award
Lederbag	Ledertasche	leather bag
Freizeitwear	Freizeitkleidung	leisure wear
Wasserboy	Wasserjunge	water boy
Bikesattel	Fahrradsattel	bike saddle
Sommersale	Sommerschlussverkaufs	summer sale
Mutti's	Muttis	Mummy's
Ausländerbashing	Beleidigung von Ausländern	bashing of foreigners
Liverwurst	Leberwurst	liver sausage
Mädelstrip	Mädelsausflug	girls' trip
Inkjetpapier	Tintenstrahlpapier	inkjet paper
Schatzis	Schätzen	darlings
Buchshop	Buchhandlung	bookshop
Studententicket	Studentenfahrkarte	student ticket
Weihnachtssong	Weihnachtslied	Christmas song
Glühweins	Glühwein	mulled wines

Appendix. CSupplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e24896.

References

[1] C. Luján García, S. García-Sánchez, Anglicisms in the field of IT (GitHub and 3D Slicer): multilingual evidence from European languages (French, German, Italian, Portuguese and Spanish), Spanish J. Eng. Stud. 41 (2020) 143–171, https://doi.org/10.24197/ersjes.41.2020.143-171.

[2] D.S. Poendaeva, V. Juri, J.V. Kobenko, E.S. Riabova, Structural characteristic of the German English hybrids of the information security sphere, MATEC Web Conf. 110 (2018) 01065, https://doi.org/10.1051/matecconf/201711001065.

[3] A. Godfroid, Eye Tracking in Second Language Acquisition and Bilingualism: A Research Synthesis and Methodological Guide, Routledge, 2020.

[4] K. Rayner, Eye movements in reading and information processing: 20 years of research, Psychol. Bull. 124 (3) (1998) 372–422, https://doi.org/10.1037/0033-2909.124.3.372.

[5] K. Rayner, Eye movements and attention in reading, scene perception, and visual search, Q. J. Exp. Psychol. 62 (8) (2009) 1457–1506, https://doi.org/10.1080/17470210902816461.

[6] J.R. Valdés Kroff, R.E. Guzzardo Tamargo, P.E. Dussias, Experimental contributions of eye-tracking to the understanding of comprehension processes while hearing and reading code-switches, Linguistic Approaches to Bilingualism 8 (1) (2018) 98–133, https://doi.org/10.1075/lab.16011.val.

[7] R. Bertram, J. Hyönä, The length of a complex word modifies the role of morphological structure: evidence from reading short and long Finnish compounds, J. Mem. Lang. 48 (3) (2003) 615–634, https://doi.org/10.1016/S0749-596X(02)00539-9.

[8] J. Hyönä, R. Bertram, A. Pollatsek, Are long compound words identified serially via their constituents? Evidence from an eye movement-contingent display change study, Mem. Cognit. 32 (2004) 523–532, https://doi.org/10.3758/BF03195844.

[9] I. Cunnings, H. Clahsen, The time-course of morphological constraints: evidence from eye-movements during reading, Cognition 104 (3) (2007) 476–494, https://doi.org/10.1016/j.cognition.2006.07.010.

[10] L. Wu, C. Xi, Eye tracking technology in detecting the switch cost in the intra-sentential code-switching contexts, Int. J. Emerg. Technol. Learn. 13 (5) (2018) 117–129, https://doi.org/10.3991/ijet.v13i05.8109.

[11] J. Grainger, C. Beauvillain, Language blocking and lexical access in bilinguals, Q. J. Exp. Psychol. 39 (2) (1987) 295–319, https://doi.org/10.1080/14640748708401788.

[12] D.W. Green, J. Abutalebi, Language control in bilinguals: the adaptive control hypothesis, J. Cognit. Psychol. 25 (5) (2013) 515–530, https://doi.org/10.1080/20445911.2013.796377.

[13] A. de Bruin, A.G. Samuel, J.A. Duñabeitia, Voluntary language switching: when and why do bilinguals switch between their languages? J. Mem. Lang. 103 (2018) 28–43, https://doi.org/10.1016/j.jml.2018.07.005.

[14] T.H. Gollan, V.S. Ferreira, Should I stay or should I switch? A cost-benefit analysis of voluntary language switching in young and aging bilinguals, J. Exp. Psychol. Learn. Mem. Cognit. 35 (3) (2009) 640–665, https://doi.org/10.1037/a0014981.

[15] M. Declerck, I. Koch, J.A. Duñabeitia, J. Grainger, D.N. Stephan, What absent switch costs and mixing costs during bilingual language comprehension can tell us about language control, J. Exp. Psychol. Hum. Percept. Perform. 45 (6) (2019) 771–789, https://doi.org/10.1037/xhp0000627.

[16] I. Kecskes, Dual and multilanguage systems, Int. J. Multiling. 7 (2) (2009) 91–109, https://doi.org/10.1080/14790710903288313.

[17] R. Otheguy, O. García, W. Reid, Clarifying translanguaging and deconstructing named languages: a perspective from linguistics, Appl. Ling. Rev. 6 (3) (2015) 281–307, https://doi.org/10.1515/applirev-2015-0014.

[18] O. García, R. Otheguy, Spanish and hispanic bilingualism, in: M. Lacorte (Ed.), The Routledge Handbook of Hispanic Applied Linguistics, Routledge, New York, 2014, pp. 639–658.
[19] V. Whitford, I. Pivneva, D. Titone, Eye movement methods to investigate bilingual reading, in: R.R. Heredia, J. Altarriba, A.B. Cieślicka (Eds.), Methods in Bilingual Reading Comprehension Research, Springer, 2016, pp. 183–211.
[20] K. Rayner, T.J. Slattery, D. Drieghe, S.P. Liversedge, Eye movements and word skipping during reading: effects of word length and predictability, J. Exp. Psychol. Hum. Percept. Perform. 37 (2) (2011) 514–528, https://doi.org/10.1037/a0020990.
[21] N. Sagarra, A. Seibert Hanson, Eyetracking methodology: a user's guide for linguistic research, Stud. Hispanic Lusophone Ling. 4 (2) (2011) 1–13, https://doi.org/10.1515/shll-2011-1113.
[22] M. Coltheart, K. Rastle, C. Perry, R. Langdon, J.C. Ziegler, DRC: a dual route cascaded model of visual word recognition and reading aloud, Psychol. Rev. 108 (1) (2001) 204–256, https://doi.org/10.1037/0033-295x.108.1.204.
[23] M. De Luca, L. Barca, C. Burani, P. Zoccolotti, The effect of word length and other sublexical, lexical, and semantic variables on developmental reading deficits, Cognit. Behav. Neurol. 21 (4) (2008) 227–235, https://doi.org/10.1097/WNN.0b013e318190d162.
[24] H.S.S.L. Joseph, S.P. Liversedge, H.I. Blythe, S.J. White, K. Rayner, Word length and landing position effects during reading in children and adults, Vis. Res. 49 (2009) 2078–2086.
[25] M.J. Cortese, D.A. Balota, Visual word recognition in skilled adult readers, in: M. Spivey, K. McRae, M. Joanisse (Eds.), The Cambridge Handbook of Psycholinguistics, Cambridge University Press, 2012, pp. 159–185.
[26] J.J.S. Barton, H.M. Hanif, L.E. Björnström, C. Hills, The word-length effect in reading: a review, Cogn. Neuropsychol. 31 (5–6) (2014) 378–412, https://doi.org/10.1080/02643294.2014.895314.
[27] K. Reinhold, E. Grabner, M. Rolfs, R. Engbert, Length, frequency, and predictability effects of words on eye movements in reading, Eur. J. Cognit. Psychol. 16 (1–2) (2004) 262–284, https://doi.org/10.1080/09541440340000213.
[28] M.A. Just, P.A. Carpenter, A theory of reading: from eye fixations to comprehension, Psychol. Rev. 8 (4) (1980) 329–354, https://doi.org/10.1037/0033-295X.87.4.329.
[29] K. Rayner, Visual attention in reading: eye movements reflect cognitive processes, Mem. Cognit. 5 (4) (1977) 443–448, https://doi.org/10.3758/BF03197383.
[30] K. Rayner, S.A. Duffy, Lexical complexity and fixation times in reading: effects of word frequency, verb complexity, and lexical ambiguity, Mem. Cognit. 14 (1986) 191–201, https://doi.org/10.3758/BF03197692.
[31] K. Rayner, G.E. Raney, Eye movement control in reading and visual search: effects of word frequency, Psychonomic Bull. Rev. 3 (2) (1996) 245–248, https://doi.org/10.3758/BF03212426.
[32] K. Rayner, E.D. Reichle, M.J. Stroud, C.C. Williams, A. Pollatsek, The effect of word frequency, word predictability, and font difficulty on the eye movements of young and older readers, Psychol. Aging 21 (3) (2006) 448–465, https://doi.org/10.1037/0882-7974.21.3.448.
[33] J. Ashby, K. Rayner, C. Clifton, Eye movements of highly skilled and average readers: differential effects of frequency and predictability, Quart. J. Exper. Psychol. Sect. A 58 (6) (2005) 1065–1086, https://doi.org/10.1080/02724980443000476.
[34] J. Hyönä, A. Pollatsek, M. Koski, H. Olkoniemi, An eye-tracking study of reading long and short novel and lexicalized compound words, J. Eye Movement Res. 13 (4) (2020) 1–18, https://doi.org/10.16910/jemr.13.4.3.
[35] S. Coats, Lexicon geupdated: new German anglicisms in a social media corpus, EuJAL 7 (2) (2019) 255–280, https://doi.org/10.1515/eujal-2019-0001.
[36] E. Jahn, German Domestic and Foreign Policy, Springer, 2015.
[37] J.W. Hunt, Lexical hybridization of English and German elements: a comparison between spoken German and the language of the German newsmagazine *Der Spiegel*, Stud. Linguist. Univ. Iagell. Cracoviensis 136 (2) (2019) 107–120, https://doi.org/10.4467/20834624SL.19.010.10605.
[38] G. Booij, Construction morphology, Language Linguistics Compass 4 (7) (2010) 543–555, https://doi.org/10.1111/j.1749-818X.2010.00213.x.
[39] L. Rennison, Angus, Thongs and Full-Frontal Snogging, Harper Collins, 1999.
[40] ERPLing Lab, Language background questionnaire. English long version. http://artsites.uottawa.ca/erplinglab/en/language-background-questionnaires/lbq-english-long-version/, 2016. (Accessed 9 September 2023).
[41] Administration for Children and Families, Head Start Program Performance Standards and Other Regulations, U. S. Department of Health and Human Services, Washington, DC, 1996.
[42] V. Marian, H.K. Blumenfeld, M. Kaushanskaya, The Language experience and proficiency questionnaire (LEAP-Q): assessing language profiles in bilinguals and multilinguals, J. Speech Lang. Hear. Res. 50 (4) (2007) 940–967, https://doi.org/10.1044/1092-4388(2007/067.
[43] CILT (centre for information on language teaching). http://www.cilt.org.uk/, 2007. (Accessed 9 September 2023).
[44] Council of Europe, Self-Assessment Grids (CEFR), Council of Europe, 2020. https://www.coe.int/en/web/portfolio/self-assessment-grid. (Accessed 9 September 2023).
[45] G.E. Raney, S.J. Campbell, J.C. Bovee, Using eye movements to evaluate the cognitive processes involved in text comprehension, JoVE 83 (2014) 1–7, https://doi.org/10.3791/50780.
[46] M. Davies, British National Corpus, Oxford University Press, 2004. https://www.english-corpora.org/bnc/. (Accessed 31 August 2023).
[47] M. Jakubicek, A. Kilgarriff, V. Kovar, P. Rychly, The TenTen corpus family, in: 7th International Corpus Linguistics Conference CL, Lancaster, 2013, pp. 125–127. https://www.sketchengine.eu//wp-content/uploads/The_TenTen_Corpus_2013.pdf. (Accessed 31 August 2021).
[48] Institute for the German Language, Mannheim German Reference Corpus/Corpora of Written Contemporary Language 2019-II Archive (Release on 7.11.2019, Institute for the German Language, Mannheim, 2019. www.ids-mannheim.de/DeReKo.
[49] K. Rayner, G.E. Raney, A. Pollatsek, Eye movements and discourse processing, in: R.F. Lorch, E.J. O'Brien (Eds.), Sources of Coherence in Reading, Erlbaum, 1995, pp. 9–35.
[50] K. Conklin, A. Pellicer-Sanchez, G. Carroll, Eye-tracking: A Guide for Applied Linguistics Research, Cambridge University Press, 2018.
[51] SR Research, SR Research Experiment Builder User Manual, SR Research Ltd., Ontario, 2015. Version 1.10.1630, http://sr-research.jp/support/files/a2ab23fd3769ea34af5d83a3429be0e2.pdf. (Accessed 1 May 2020).
[52] K. Conklin, A. Pellicer-Sanchez, Using eye-tracking in applied linguistics and second language research, Sec. Lang. Res. 32 (3) (2016) 453–467, https://doi.org/10.1177/0267658316637401.
[53] G.D. Keating, Eye-tracking with text, in: J. Jegerski, B. VanPatten (Eds.), Research Methods in Second Language Psycholinguistics, Routledge, 2014, pp. 69–92.
[54] R Core Team, R: a language and environment for statistical computing. http://www.R-project.org, 2019. (Accessed 31 August 2021).
[55] D. Bates, M. Mächler, B. Bolker, S. Walker, Fitting linear mixed-effects models using lme4, J. Stat. Software 67 (1) (2015) 1–48, https://doi.org/10.18637/jss.v067.i01.
[56] D. Lüdecke, sjPlot: data visualization for statistics in social science. R package version 2.8.9. https://CRAN.R-project.org/package=sjPlot, 2021. (Accessed 31 August 2021).
[57] C. Stein, A. Wald, Sequential confidence intervals for the mean of a normal distribution with known variance, Ann. Math. Stat. 18 (3) (1947) 427–433. http://www.jstor.org/stable/2235738.
[58] D.J. Barr, R. Levy, C. Scheepers, H.J. Tily, Random effects structure for confirmatory hypothesis testing: keep it maximal, J. Mem. Lang. 68 (3) (2013), https://doi.org/10.1016/j.jml.2012.11.001.
[59] E. Adamou, R. Shen, There are no language switching costs when codeswitching is frequent, Int. J. BiLing. 23 (1) (2019) 53–70.
[60] J.W. Gullifer, P.E. Dussias, When language switching has no apparent cost: lexical access in sentence context, Front. Psychol. 4 (2013) 278, https://doi.org/10.3389/fpsyg.2013.00278.
[61] A. Ibáñez, P. Macizo, M.T. Bajo, Language access and language selection in professional translators, Acta Psychol. 135 (2) (2010) 257–266, https://doi.org/10.1016/j.actpsy.2010.07.009.
[62] G.M. Jackson, R. Swainson, A. Mullin, R. Cunnington, S.R. Jackson, ERP correlates of a receptive language-switching task, Q. J. Exp. Psychol. 57A (2) (2004) 223–240, https://doi.org/10.1080/02724980343000198.

[63] E.M. Moreno, K.D. Federmeier, M. Kutas, Switching languages, switching palabras (words): an electropysiological study of code switching, Brain Lang. 80 (2) (2002) 188–207, https://doi.org/10.1006/brln.2001.2588.
[64] M. Mosca, H. Clahsen, Examining language switching in bilinguals: the role of preparation time, Biling. Lang. Cognit. 19 (2) (2016) 415–424, https://doi.org/10.1017/S1366728915000693.
[65] N. Hakimov, Effects of frequency and word repetition on switch placement: evidence from Russian-German code-mixing, in: M. Reif, J.A. Robinson (Eds.), Cognitive Approaches to Bilingualism, Mouton de Gruyter, 2016, pp. 91–125.
[66] N. Hakimov, Lexical frequency and frequency of co-occurrence predict the use of embedded-language islands in bilingual speech: adjective-modified nominal constituents in Russian-German code-mixing, J. Lang. Contact 13 (3) (2021) 501–539, https://doi.org/10.1163/19552629-bja10028.