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Hearing a code-switch increases bilinguals' attention to and memory for information

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ABSTRACT

In conversation with each other, bilinguals sometimes code-switch between their shared languages. While psycholinguistic research often highlights the challenges of processing code-switches compared to single-language utterances, bilinguals seem to navigate code-switching with ease. Alongside empirical evidence that code-switching does not always disrupt comprehension in natural contexts, this raises intriguing questions about the potential benefits of code-switching. We propose that code-switching enhances bilingual listeners' attention to the speech signal, improving the encoding and memory of linguistic messages near the switch. In Experiment 1, Spanish-English bilinguals listened to code-switched and single-language stories, occasionally reported their attention levels, and later answered comprehension questions. They reported greater attention to and demonstrated increased memory for code-switched content. Experiment 2 tested whether this attentional effect was simply due to the saliency of language changes by having English-speaking monolinguals complete the same task. Although monolinguals showed better memory when reporting higher attention, they did not show increased attention following code-switches. These findings suggest that bilinguals' experience with the communicative contexts in which code-switches typically occur enables them to focus their attention on speech content during a code-switch, aiding in their collection and retention of that content over time.

Introduction

During conversations, bilinguals may naturally switch between their languages, a behavior known as *code-switching*. This phenomenon involves alternating from one language to another and requires cross-linguistic integration across multiple levels of representation, such as phonological, morphosyntactic, and semantic (Poplack, 1980).

While code-switching is a natural use of a bilingual speaker's full linguistic repertoire (Beatty-Martínez et al., 2020a; Otheguy et al., 2015), it can introduce processing challenges for bilingual comprehenders. For instance, bilinguals take longer to read code-switched sentences compared to single-language equivalents (Altarriba et al., 1996; Bultena et al., 2015), and encountering a code-switch during real-time comprehension generates electrophysiological brain activity associated with processing difficulty (e.g., Litcofsky & Van Hell, 2017). These costs have been attributed to various time-consuming cognitive operations, including resolving the conflict that arises when integrating input from two languages, suppressing the prior language following a switch, and/or promoting the switched-into language that was previously inhibited (Adler et al., 2020; Litcofsky & Van Hell, 2017).

However, other research shows no difficulties associated with understanding code-switches (Adamou & Shen, 2019; Gosselin & Sabourin, 2021; Johns et al., 2019), at least not when processing naturalistic, common types of switches (Salig et al., 2024). Notably, bilinguals code-switch during spontaneous conversations under specific pragmatic conditions (e.g., in the presence of another familiar bilingual or in informal contexts) with no obvious detriment to communication (Gardner-Chloros, 2009; Poplack, 1980; Torres Cacoullos & Travis, 2018).

Indeed, the reality is that bilinguals frequently engage in code-switching, even though engaging in costly behavior without reason would not be efficient or pragmatically appropriate (Clark, 1996). While code-switches can sometimes introduce processing costs during comprehension—typically measured on the millisecond scale in controlled,

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context-free laboratory settings—emerging psycholinguistic research suggests that code-switches may also offer significant benefits to bilingual listeners that enable successful communication (e.g., Valdés Kroff & Dussias, 2023).

Based on this understanding, we test the hypothesis that code-switches enhance bilingual listeners' attention to the speech signal during story listening, potentially affecting their memory for information presented around the code-switch. In what follows, we explore various accounts that describe how a relationship between code-switches and attention may form and the extent to which it does.

Code-switches and Attention: Three Accounts

Attention is a multicomponent cognitive system that enables individuals to process sensory input, sustain concentration during tasks, and gather information over time (Petersen & Posner, 2012; Posner & Petersen, 1990). It includes distinct functions, such as alerting and orienting (Petersen & Posner, 2012). Alerting achieves and maintains a state of cognitive readiness, preparing the system to handle incoming information. Orienting involves the ability to selectively attend to specific information from the sensory input. These functions work together to facilitate the successful collection and processing of relevant information. Here, we focus on how listeners orient their attention to the linguistic content of speech, particularly in contexts where code-switching occurs. Code-switching, as an interactive feature of bilingual communication, may act as a linguistic cue that orients attention, engaging processes that support comprehension, encoding, and memory consolidation, as opposed to simply maintaining general alertness.

In this section, we sketch various ways in which code-switches might dynamically influence bilinguals' attention and, consequently, their memory for information presented in code-switched input. We will focus on two main explanations for how code-switches could heighten attention to the speech signal, but to distinct features of the input with fundamentally different effects on memory.

Account 1. Orienting Account: Code-switches direct attention to the content of language input. One possibility is that, when hearing a code-switch, listeners orient their attention to speech content, enhancing their ability to collect, encode, and later remember information compared to content that has not been code-switched.

A beneficial orienting effect of code-switches may stem from listeners' prior experience with code-switching, shaped by their exposure to and interaction with other bilinguals who code-switch, as well as by the broader community's acceptance of this practice (Torres Cacoullos & Travis, 2018). Knowledge about the conditions under which a speaker is likely to code-switch may enable a listener to infer the type of information a code-switch carries, modulating attention to accommodate that inference. For example, code-switches often occur before words that might be unexpected or surprising from the comprehender's perspective (Calvillo et al., 2020; Myslín & Levy, 2015). A visual-world eye-tracking study demonstrated that bilingual listeners are sensitive to such probabilistic occurrences: Although participants' eye-gaze patterns showed anticipation of high-frequency referents after hearing single-language input (as is typical; see Dahan et al., 2001), participants anticipated *low-frequency* referents after hearing a code-switch (Tomić & Valdés Kroff, 2022). Thus, bilinguals with sufficient code-switching experience may infer the communicative intent of a code-switch regarding its sentential or pragmatic content (e.g., a switch may signal upcoming mention of a rarer object) and increase their attention to that content accordingly.

While there are several reasons why a speaker may code-switch—such as retrieval difficulty, marking identity, or as a rhetorical device (e.g. Gumperz, 1982)—our focus here is not on production choices. The central idea of our proposal is that bilingual listeners are sensitive to the various reasons behind code-switching. As a result, they learn to draw appropriate inferences when a speaker switches languages, recognizing that these switches often correspond to pragmatically significant information, such as topic changes, production difficulties, or the introduction of salient or unexpected content. We speculate that this inference process, which likely develops through bilingual experience, may heighten listeners' attention to the content of linguistic input when they encounter a code-switch.

Knowledge-driven or salient signal-change? So far, we have proposed that code-switching may orient listeners' attention based on their bilingual knowledge about how code-switches are typically used. However, an orienting effect may not necessarily require an inference by the listener: The beneficial effect of code-switches on attention and memory could arise from the signal change itself, independent of the listener's experience and knowledge.

A code-switch involves a shift between phonological systems—relatively low-level acoustic properties of the signal—and such a shift could naturally orient listeners' attention to the speech content. Specifically, the change in language may be salient enough to direct listeners' attention to the message in the input through a bottom-up process (see Diachek & Brown-Schmidt, 2022; Fraundorf & Watson, 2011 for a similar account applied to disfluency processing).

Regardless of whether an orienting effect stems from bilingual knowledge or a signal-driven mechanism, it should lead to increased attention to the speech signal—specifically, to the information it carries. We hypothesize that this increased attention to linguistic input will result in better memory for content surrounding a code-switch compared to non-switched input.

To distinguish between the knowledge-driven and signal-change accounts, one promising step is to test how functionally monolingual listeners respond to code-switches. While it may initially seem counterintuitive to expose monolinguals to code-switches, their unfamiliarity with the pragmatic functions of code-switching provides a unique opportunity to tease apart these two orienting mechanisms. When monolinguals hear a code-switch, any effect on their attention could only be driven by the change in the signal, not by experience with code-switches as meaningful communicative cues. Since monolinguals lack the bilingual experience and associated inferential framework for processing code-switches, their responses can help clarify whether the orienting effect arises from bilingual knowledge or from salient signal changes—an issue we revisit later.

Account 2. Diverting Account: Code-switches increase attention to auditory input but divert attention from speech content. Instead of orienting listeners' attention to content surrounding a switch, code-switches might capture listeners' attention and draw it *away from* information conveyed in the input.

Myslín and Levy (2015) suggest that code-switches serve as a marked or distinct type of speech that captures attention because of phonological changes. In bilingual conversations, most utterances are *not* code-switched (Beatty-Martínez et al., 2020a; Fricke & Kootstra, 2016; Piccinini & Arvaniti, 2015), so a switch between languages may be perceptually salient. Earlier, we suggested that the saliency of the phonological change may orient attention to the linguistic message in a bottom-up way that helps the listener collect and later remember the information conveyed in the switch. However, an alternative possibility is that the phonological change may *seize* attention, disengaging it from sentential or pragmatic content. This may be akin to an 'acoustic oddball effect,' where unexpected sounds distract from a central task, impairing detection of a subsequent auditory target (e.g., Dalton & Lavie, 2004).

Under this account, although attention to the auditory signal is increased at a code-switch, it is captured by a distracting, salient change in sound patterns that does not facilitate greater information collection. If this is the case, then bilinguals' memory for information around the switch should not be better *and in fact may be worse* than for single-language material. This is because attention is not specifically oriented to input of communicative value, but rather captured by a signal change, which disrupts information collection and negatively impacts memory. Such an account could align with the traditional observation of switch costs, wherein processing a code-switch presents difficulty during real-time comprehension.

Comparing the Two Attention-boosting Accounts. Both the orienting and diverting accounts propose that code-switches increase attention to the speech signal, albeit to different aspects of the signal.

Under both accounts, the attentional increase is expected to be localized, occurring immediately at the point of the switch and sustaining briefly afterward, consistent with established models of attentional mechanisms (Petersen & Posner, 2012). However, the duration and scope of this effect remain open empirical questions. One possibility is that code-switches induce a broader, global alerting effect, enhancing attention throughout the entire context of a code-switched interaction rather than only near the switch points. In the current study, we explicitly test whether the attentional adjustment is a localized effect—focused specifically on linguistic content near the switch—or reflects a broader, global impact on attention. Disentangling these local versus global effects is crucial for clarifying the mechanisms through which code-switching influences bilinguals' attention and memory for linguistic information.

The key distinction between the orienting and diverting accounts lies in their predicted impacts on memory for linguistic content. According to the orienting account, code-switches act as cues that direct attention specifically to the message content, enhancing encoding and leading to better memory for information near the switch compared to single-language material. In contrast, the diverting account posits that code-switches are salient phonological disruptions that momentarily capture attention but divert it from the linguistic message. This diversion could result in no memory benefit—or even reduced memory—for information near the switch, as attention is temporarily pulled away from the message, causing the listener to miss crucial information.

In summary, while both accounts predict an attentional boost, they differ in their downstream effects on memory: The orienting account predicts improved memory for switched content, whereas the diverting account predicts no benefit—or a detriment—for such content.

Account 3. Null Account: Code-switches do not modulate attention. It is possible that code-switches may not affect listeners' attention or memory. In natural bilingual interactions, where speakers use their full linguistic repertoire, code-switches might not engage attention any differently than single-language content. The phonological change in code-switches may seem typical rather than salient, and listeners may perceive switches as unremarkable and not inherently meaningful.

However, this scenario seems unlikely given the evidence that bilingual listeners detect code-switches early during language processing (Kuipers & Thierry, 2010) and can use them as a predictive cue to comprehension (Tomić & Valdés Kroff, 2022). Sociolinguistic studies also suggest that code-switching serves various communicative functions beyond lexical accessibility (Gumperz, 1982). Thus, bilinguals appear to be attuned to both the phonological changes associated with a code-switch and its pragmatic functions, indicating that these sensitivities may influence their attentional focus when encountering a code-switch.

Indeed, prior work has suggested a relationship between attention and code-switching (Beatty-Martínez et al., 2021; Green, 2019; Salig et al., 2021; see also Bialystok & Craik, 2022; Nijmeijer et al., 2022; Timmer et al., 2021a; Timmer et al., 2021b). For instance, two studies found that bilinguals exhibit greater attentional alerting during a non-linguistic task when presented within a mixed-language context compared to a single-language context (Timmer et al., 2021a; Timmer et al., 2021b). However, much of the current research primarily focuses on the differential attentional demands in *producing* different types of code-switches (e.g., insertional, single-word switching vs. alternational, multi-word switching) or group-level differences in attentional control. No work has specifically examined how code-switches may dynamically affect bilinguals' attention during real-time comprehension. The research we present here addresses this gap, exploring fluctuations in attention during the normal course of story listening and testing the link between attention and memory.

Considering a Continuum of Bilingualism. We have delineated three accounts of how code-switches might influence attention. Of course, it is plausible that code-switches can have varying attentional effects on bilinguals, depending on their life experiences, language proficiencies, and community-supported usage patterns. For instance, habitual code-switchers—bilinguals who frequently produce and encounter code-switches in daily communication—might infer pragmatic meanings from code-switches, directing their attention towards speech content. Conversely, bilinguals who rarely or never code-switch may find their attention captured by the phonological change that they are less accustomed to processing. Additionally, speakers use code-switching to convey a range of communicative functions, which may lead listeners to engage attentional resources differently depending on the environmental and pragmatic conditions present. The above accounts therefore are not necessarily mutually exclusive, as code-switching experience could influence bilinguals' ability to infer meaning from code-switches or how they process code-switches (Beatty-Martínez & Dussias, 2017; Gosselin & Sabourin, 2021; Valdés Kroff et al., 2018). Consequently, we hypothesize that code-switching experience may interact with the attentional effects of hearing code-switches.

In the experiments reported below, we did not manipulate the pragmatic function for the code-switches that listeners heard, choosing to present naturalistic code-switches embedded in long stories. This research serves as an initial step toward differentiating among the proposed accounts and assessing whether code-switching experience influences the impact of code-switching on attention and memory. These insights could lead to a deeper understanding of the varied outcomes observed in prior studies of switch costs during online processing.

The Current Experiments: Preliminaries and Predictions

We conducted two experiments to examine the effects of code-switched input on the attention and memory of Spanish-English bilinguals (Experiment 1) and English-speaking monolinguals (Experiment 2) during naturalistic story listening. Participants listened to both single-language and code-switched stories while periodically indicating their attention levels. Afterward, they answered comprehension questions to assess memory retention.

We hypothesized that bilinguals would report higher attention levels during code-switched content compared to single-language content, and that better-attended information would be more accurately remembered (e.g., Boudewyn & Carter, 2018). Our experimental approach aimed to distinguish between local and global effects of code-switches on attention, testing whether these switches influence bilinguals' attention throughout an entire code-switched story (even during single-language sections) or only at points near the switches. Additionally, we predicted that code-switches would influence memory for information, with bilinguals' code-switching experience potentially affecting the observed attention and/or memory effects.

To preview our results, bilinguals reported higher attention levels during code-switched content, with this effect localized to the points of code-switching. They also demonstrated significantly better memory for material near code-switches compared to material in single-language contexts, supporting the orienting account. Interestingly, however, bilingual code-switching experience did not influence the attention effect.

Experiment 2 was designed to explore whether these effects could be solely attributed to the saliency of the switch between languages. By examining monolingual participants' responses to code-switched material, we aimed to distinguish between purely stimulus-driven effects and those influenced by bilingual experience. While unusual, given that monolinguals cannot comprehend content in the other language, this approach allowed us to differentiate between two explanations of our findings: the purely bottom-up orienting account, which suggests that attentional effects stem from the novelty or incongruity of the language switch, and the higher-level orienting account, which posits that bilinguals' heightened attention to information around a switch is influenced by their sensitivity to code-switching contexts. Notably, in the code-switched context, the majority of the story was presented in English, so the code-switches did not pose a significant obstacle to overall comprehension.

We found that monolinguals had better memory for content that they paid closer attention to, validating our attention measure. However, in contrast to bilinguals, monolinguals did not exhibit an attentional increase in response to code-switches; instead, they reported higher attention levels to single-language content. This finding challenges a purely bottom-up signal-change account, which would predict similar attention effects in both groups. Our results therefore highlight that the attention and memory effects of code-switches in bilinguals are influenced by their linguistic experience, including their sensitivity to the context and communicative intent conveyed by a code-switch, underscoring the role of experience-driven knowledge.

Data Availability

The materials, analysis scripts, and partial data for both experiments are available on OSF (https://osf.io/fuahq/). For Experiment 1, data are available for the 97 % of participants who consented to data sharing. For Experiment 2, data are available for the 76 % of participants who consented to data sharing. As not all participants consented to data sharing, the results presented below cannot be fully replicated using the data available on OSF.[1]

Experiment 1 Method

The method and analyses for Experiment 1 were pre-registered (https://osf.io/x2vbz). Experimental tasks were approved by the University of Maryland's Institutional Review Board. Participants provided informed consent and received $12/hour.

Participants

We recruited Spanish-English bilinguals based in the U.S. through Prolific (https://www.prolific.com/). As outlined in our preregistration, we aimed to recruit 100 participants for the main experimental task to achieve an acceptable level of power for within-subjects comparisons in bilingualism research (Brysbaert, 2021). Participants first completed a qualifying survey, which included the Bilingual Code-switching Profile (BCSP; Olson, 2024), a validated tool for assessing self-reported code-switching background and use. The survey also included questions about their language history and LexTALE vocabulary assessments in both English and Spanish (Izura et al., 2014; Lemhöfer & Broersma, 2012). Of the 182 bilinguals who completed the survey, 132 qualified and were invited to participate in the main study. To qualify, participants had to indicate that Spanish and/or English was their first and most-preferred language, and they had to score 55 % or higher on both LexTALE assessments.

Ninety-six out of the 132 accepted our invitation to complete the main study, which occurred in a separate experimental session, bringing our sample size close to the target of 100. We excluded data from four participants who did not meet pre-registered criteria: Three gave the same response to all attention probes, and one failed all engagement checks (see below). The remaining 92 bilinguals (39 women, 36 men, 1 of another gender, and 16 who did not report gender) appeared mostly English dominant, although it is important to note that the LexTALE relies on the evaluation of written vocabulary and may underestimate Spanish proficiency for our U.S.-based participants, who likely had more verbal than written exposure to Spanish. Importantly, our bilingual sample represented varied first language backgrounds: 43 had English as their first language, 25 had Spanish, and 24 had acquired both Spanish and English from birth. They also had moderate, but varied, code-switching experience (see Table 1). Six participants reported that they did not code-switch, but those who did started relatively early in life (M = 10.41 years, SD = 6.12). On average, the bilinguals had spent approximately 14.07 years in a region/community where switching languages is common, and they seemed to code-switch more in family settings than in other settings (e.g., work or school).

Table 1
Bilingual Participants' Characteristics (n = 92).

	Mean (SD)
Age (years)	33.36 (10.29)
AoA English (years)	1.51 (2.80)
AoA Spanish (years)	5.24 (8.23)
English LexTALE score (out of 100)	91.93 (8.81)
Spanish LexTALE score (out of 100)	69.66 (11.50)
Language Exposure Entropy (from 0 to 1.58)	0.81 (0.30)
BCSP score (out of 100)	48.58 (12.45)

Note. AoA = Age of Acquisition. Language Exposure Entropy was calculated based on participants' self-reports of what percentage of their daily time on average they are exposed to English, Spanish, or other languages (higher indicates more balanced exposure; Gullifer & Titone, 2020). BCSP = Bilingual Code-switching Profile, which measures code-switching experience (higher indicates more code-switching experience/engagement).

Materials and Design

The study materials, including links to the audio files on GitHub, are available in the OSF repository (https://osf.io/fuahq/). Participants completed the experiment remotely using PCIbex (Zehr & Schwarz, 2018). Each participant listened to two Sherlock Holmes stories, adapted from Boudewyn and Carter (2018): one story entirely in English and the other mostly in English but with code-switches into Spanish. The stories were approximately 35 minutes long (to reduce study length, audio files were sped to 1.07x the original rate, which still sounded natural). The stories were recorded by an early Colombian-Spanish/American-English bilingual woman who frequently code-switches in her daily life. She was raised in South Florida, a highly bilingual geographic area of the U.S. with many Spanish dialects in contact. She exhibited the characteristics of early Spanish-English bilingual speakers of the region, including dialect features prevalent in Miami English (Carter & Lynch, 2015; Carter et al., 2020) and in Spanish influenced by contact with multiple dialects of Latin American Spanish and American English.

Attention Probes. During the stories, an attention probe appeared approximately every 1–2 minutes, following a method from the mind-wandering literature (e.g., Mooneyham & Schooler, 2013; Smallwood et al., 2008). Each story had 24 or 25 probes. When a probe appeared, the story paused, and participants had ten seconds to report their attention level. They did so by selecting a point anywhere along a vertical line, where a red-face icon at the bottom indicated being off-task, a yellow-face icon at the midpoint represented split-attention, and a green-face icon at the top indicated fully on-task attention (see Fig. 1). Participants' responses were recorded as a value on a continuous 100-point (0–99) scale. The scale was explained before the study; participants were encouraged to respond honestly and were assured that their responses would not affect compensation. Trials without responses to a probe were re-coded as that person's lowest-used attention response value within that story. It is important to note that while this approach measures attention subjectively, it is not arbitrary: Responses to similar attention probes reliably correlate with objective measures of attention, including neural oscillations in the alpha band from scalp-recorded

[1] Re-running the analyses using only the shareable data yields the same pattern of results reported in this manuscript. These reproducible analyses and results are available on OSF.

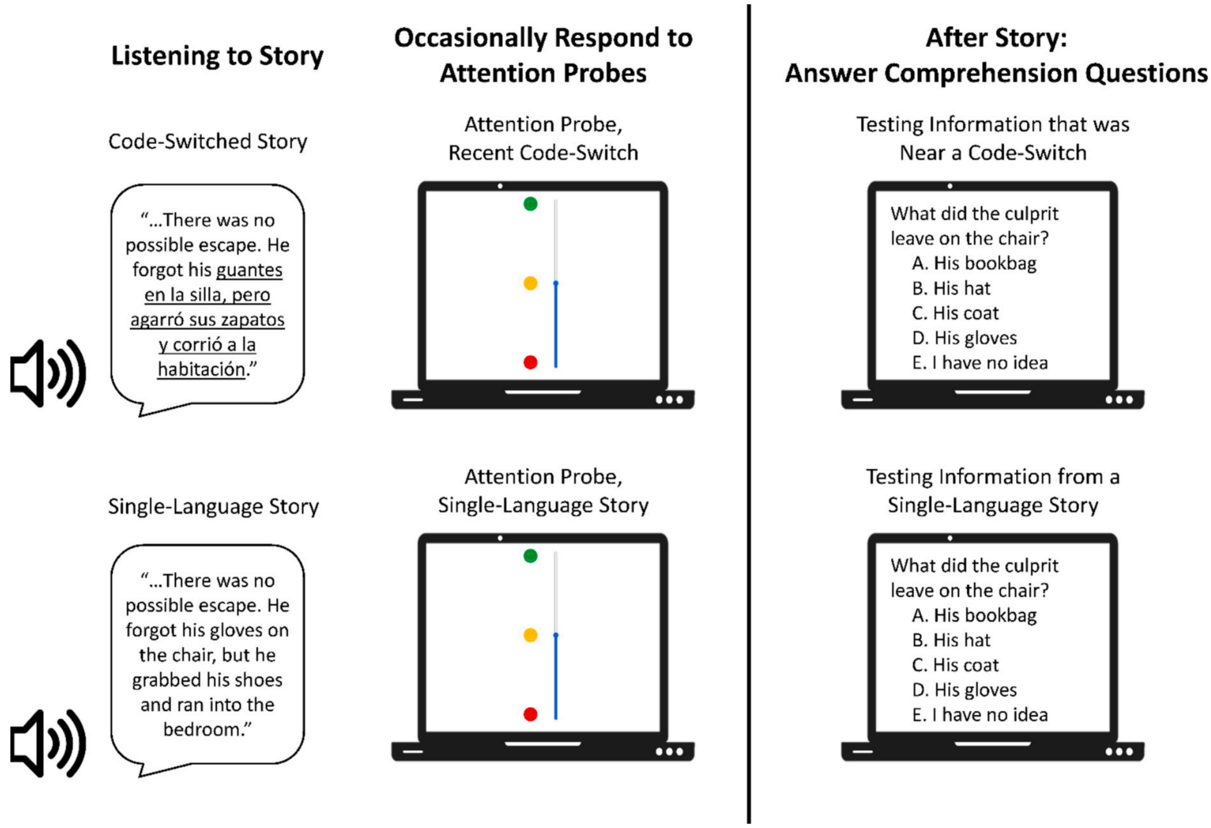

Fig. 1. Study Schematic with Example Stimuli. The illustration represents two of the three conditions: An attention probe after a recent code-switch in the code-switched version of a story (top panel), and an attention probe in the single-language version of the same story (bottom panel). Each participant heard only one version of each story, code-switched or single-language. There was also a third condition (not illustrated): Attention probes in the code-switched story but after single-language content (far from a code-switch). After the stories were over, comprehension questions assessed memory for information that had appeared near a code-switch, far from a code-switch, or in a single-language story.

electroencephalography (Boudewyn & Carter, 2018). Moreover, responses to such attention probes reliably predict expected behavioral outcomes; for example, participants who report lower attention tend to perform less accurately on error detection and comprehension questions compared to when they report higher attention (see Mooneyham & Schooler, 2013 for a review).

Code-switching Manipulation. To create the code-switched versions, we inserted English-to-Spanish switches shortly before approximately half of the attention probes (within three sentences) in the original English-only stories. In the code-switched versions, one story included critical code-switches shortly before 11 of the 24 attention probes, and the other included critical code-switches shortly before 15 of the 25 attention probes. This design allowed us to measure attention *near* a recent code-switch, assessing the immediate impact of hearing a code-switch on attention in real time (see Fig. 1). The remaining attention probes in the code-switched stories occurred after stretches of single-language content, *far* from any recent code-switch. These probes enabled us to assess whether exposure to code-switches in the broader context of a story influenced attention even when no immediate code-switch preceded the probe. Accordingly, we categorized our Language Context variable just before each attention probe into three levels: single-language story, recent code-switch in a code-switched story, and far from a code-switch in a code-switched story.

Code-switches were naturally spoken and recorded without splicing. Audio files were edited to remove lengthy silences and errors. Story version (code-switched vs. single-language) and the order of the two stories were counterbalanced across participants, resulting in four possible lists to which participants could be assigned: Story1CodeSwitched-Story2SingleLanguage ($n = 25$), Story1SingleLanguage-Story2CodeSwitched ($n = 22$), Story2CodeSwitched-Story1SingleLanguage ($n = 22$), and Story2SingleLanguage-Story1CodeSwitched ($n = 23$).

Critical code-switches were intrasentential and alternational, occurring within sentences at noun or verb phrases. Following the switch, the content remained in Spanish until after the next attention probe. Within the U.S., Spanish-English bilinguals vary in community-supported switching patterns, with East Coast bilinguals and those from Puerto Rico primarily engaging in Spanish-to-English code-switches (Deuchar et al., 2014; Guzzardo Tamargo et al., 2019) while communities in New Mexico show no preferred direction (Torres Cacoullos & Travis, 2018). Though English-to-Spanish switches are less common in the U.S., they do occur naturally (Poplack, 1980), and our hypotheses make no predictions about switching direction. We return to the topic of community-based switch direction in the General Discussion.

To ensure that our materials reflected authentic code-switching, we conducted a separate norming study with 49 Spanish-English bilinguals on Prolific. Participants rated the naturalness of our critical code-switches on a 1–9 scale and judged them as relatively natural ($M = 6.53$, $SD = 0.78$), significantly more so than intentionally ill-formed code-switches ($M = 4.77$, $SD = 0.90$, $p < 0.01$). Any experimental switches rated poorly in this norming phase were revised to improve their naturalness. Thus, our final materials were designed to reflect realistic and natural code-switching patterns.

To prevent participants from reliably predicting an upcoming attention probe based solely on the occurrence of a code-switch, we strategically inserted 5–6 filler code-switches into the code-switched stories. The filler code-switches were placed at least five sentences away from the next attention probe, occurred at varied syntactic sites, and included at least one sentence in Spanish before switching back to English, equivalent to the amount of Spanish in the critical code-switches. With 11–15 critical code-switches and 5–6 filler code-switches, attention probes followed approximately two-thirds of the code-switches. This intentional inconsistency likely prevented participants from learning an association between code-switches and probes.

Overall, approximately 5 % of the words in the code-switched stories were in Spanish, a proportion within the range of what occurs naturally in bilingual speech (see Fricke & Kootstra, 2016). Moreover, the code-switched segments occurred at morphosyntactic sites considered typical and naturalistic in the Spanish-English code-switching literature (Poplack, 1980), which our norming data corroborated. Care was taken to limit Spanish dialect differences across lexical items and morphosyntactic features, with Spanish-speaking research assistants and co-authors independently verifying the intelligibility of the stories. In fact, in Experiment 1, participants rated the overall naturalness of the code-switched stories at a 5.33 out of 7 ($SD = 1.48$), further supporting that the stories seemed natural to listeners. Notably, bilinguals with more code-switching experience tended to rate the stories as more natural ($r = 0.24$, $p < 0.001$), indicating that our materials resonated particularly well with individuals familiar with code-switching in everyday communication.

Post-story Memory Assessment. After listening to each story, participants answered multiple-choice comprehension questions in English (modified from Boudewyn & Carter, 2018) that tested memory for story material preceding attention probes (Fig. 1). One story had 30 comprehension questions, and the other had 44, following the original paradigm from Boudewyn & Carter (2018).

After the code-switched story, questions tested material that appeared either near or far from a code-switch. Note that this design feature was necessary to test whether memory for story content was directly linked to a local code-switching event, or more broadly to a general code-switching story context. However, it also created an asymmetry in our comprehension questions: Questions that tested memory for information near code-switched material mostly probed content that was presented in Spanish, whereas questions that tested memory for information far from code-switched material probed content that was presented in English. We return to this issue in the Experiment 1 Discussion. To assess bilinguals' attention while they heard the information interrogated by the question, we used their responses from the nearest attention probe after the relevant story material. This helped test whether attention influenced later memory for content.[2]

Engagement Checks. We included four engagement checks, one early in the study and three intermixed with comprehension questions, which instructed participants to select a specific answer to evaluate general engagement with the experimental task. For example, one engagement check question instructed: "For this question, please select the letter B (Watson) as your answer. This is to check that you are engaged in the study task."

Study Experience Questions. After completing the study, participants answered questions about their experience, including how much they enjoyed each story, how honestly they responded to attention probes, which story they paid more attention to, and their language preference for the stories. While these responses do not directly contribute to the investigation of our main hypotheses and are not addressed further in this paper, a descriptive analysis of participants' responses, along with pre-registered analyses regarding story enjoyment, are available in the data analysis script on OSF.

Experiment 1 Results

Analyses were pre-registered unless indicated as exploratory. Linear mixed effects models were conducted in R (R Core Team, 2020, version 4.0.2) using the lmerTest package (Kuznetsova et al., 2017), which approximates p-values using the Satterthwaite degrees of freedom method. Partial eta squared effect sizes were calculated using the sjstats package (Lüdecke, 2022). Random effects structures were pre-registered and included random slopes and intercepts by participant and by item but were simplified as needed to reach model convergence; final model specifications, including random effects, are in the Notes section of the model tables below.[3]

In our analyses, we used a pre-registered orthogonal coding approach to compare performance in two ways: (1) between the single-language story and the code-switched story as a whole, and (2) between the code-switched sections and the single-language sections within a code-switched story. This approach enabled us to assess whether code-switches exerted a global effect on attention and memory across the entire code-switched story (by comparing overall performance in code-switched vs. single-language stories) or a localized effect specifically at the points of the switches (by comparing performance on code-switched content to single-language content within the code-switched story).

Effects of Code-switching on Bilinguals' Attention

As can be seen in Fig. 2, bilinguals reported greater attention after a recent code-switch ($M = 78.58$, $SD = 16.11$) compared to when probed far from a code-switch ($M = 73.85$, $SD = 18.26$), and compared to when probed in a single-language story ($M = 73.57$, $SD = 19.07$). This pattern aligns with our prediction, and a multiple regression model (Table 2) confirmed this observation: Within code-switched stories, bilinguals reported significantly greater attention after recent code-switches than when probed far from code-switches ($p < 0.01$, $\eta_p^2 = 0.10$). There was no significant attention difference in code-switched stories overall compared to single-language stories ($p = 0.06$). Together, these results provide no evidence that code-switches increased attention *throughout* a code-switched story; instead, the results suggest that the attentional increase was localized to story sections that were near a code-switch, not sections that were far from a code-switch (i.e., in a stretch of single-language input).

We also hypothesized that code-switching experience (measured by BCSP score) would interact with attentional modulations driven by code-switches, but this pattern did not emerge ($ps > 0.11$). To further investigate this, we conducted an exploratory correlation analysis to determine whether bilinguals with more code-switching experience showed a greater attention boost near code-switches. However, the magnitude of the attention effect (attention near code-switches minus attention far from code-switches) was not correlated with BCSP scores (r

[2] Because our study involved remote participation over the internet, we first conducted a validation study with English-speaking monolinguals who listened to English-only versions of the stories (pre-registered at https://osf.io/g92at/). We found that greater self-reported attention to information predicted higher accuracy when tested on that information later ($p<0.01$), replicating the link between attention and memory observed in prior in-person studies (Boudewyn & Carter, 2018; Smallwood et al., 2008). Additionally, we found that story identity (i.e., Story 1 vs. Story 2) did not predict attention probe responses ($p=0.97$) or comprehension question accuracy ($p=0.44$), indicating that both stories were matched in interest and difficulty when presented in English. Data are available on OSF. Note that this validation study is distinct from Experiment 2, reported below, in which English-speaking monolinguals heard both English-only and code-switched stories, like the bilinguals in Experiment 1.

[3] After the study, we asked participants if they had previously read either story and if they had an attention disorder or took medication for one. The pattern of results did not change when we removed 3 participants who reported story familiarity or 15 participants who reported an attention disorder or medication. The pattern of results also did not change when we removed 10 participants who had below chance accuracy (<25%) on the comprehension questions.

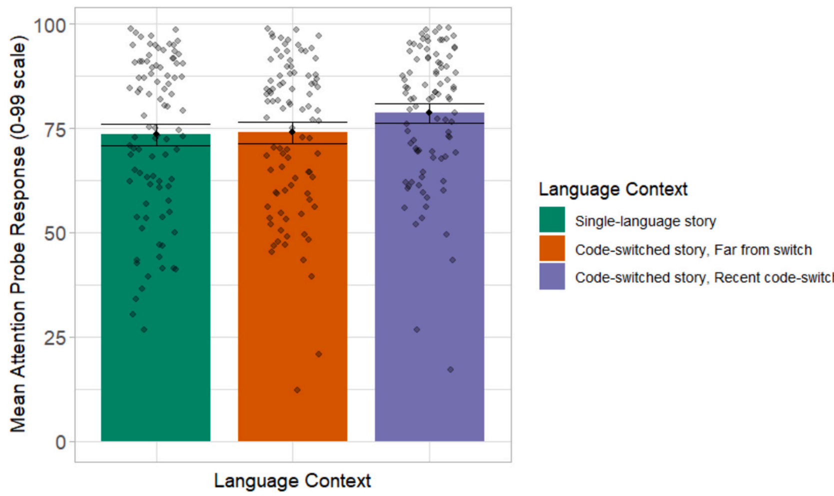

Fig. 2. Bilinguals' Attention Responses by Language Context. Mean self-reported attention, split by language context. Bars represent standard error. Dots indicate individual participants' average probe response in each language context.

Table 2
Pre-Registered Regression Model Predicting Bilinguals' Attention from Language Context.

Factor	β	SE	t	p
Intercept	0.43	1.76	0.25	0.81
Language Context: Single-language story vs. Code-switched story	2.71	1.40	1.94	0.06
Language Context: Far vs. Near a code-switch	**3.26**	**1.00**	**3.26**	**<0.01**
BCSP Score	−0.12	0.14	−0.87	0.39
Language Context: Single-language vs. Code-switched story * BCSP Score	−0.18	0.11	−1.59	0.12
Language Context: Far vs. Near code-switch * BCSP Score	−0.03	0.07	−0.39	0.70

Note. Model specification: CenteredProbeResponse ~ LanguageContext * BCSPScore + (LanguageContext | Participant) + (1 | Probe). Language Context was orthogonally coded.

= -0.03, p = 0.77; see Fig. 3). A Bayes Factor of 0.25 provided some evidence in favor of the null hypothesis.

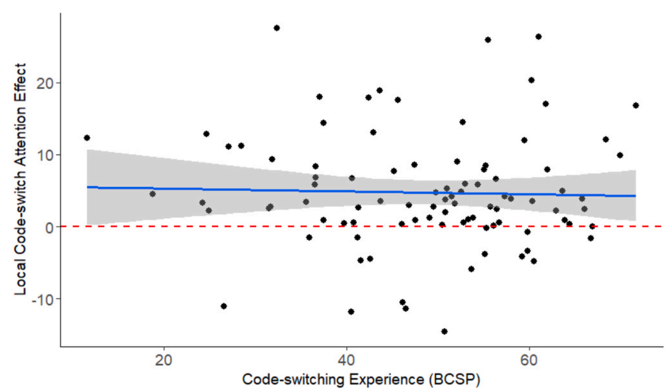

Fig. 3. Attention Effect of Code-switches by Bilinguals' Code-switching Experience. Exploratory correlation between the magnitude of the attention effect (mean attention near code-switches minus mean attention far from code-switches) and BCSP scores (which can range from 0 to 100). The blue line represents a linear fit of the data, with the gray shading indicating the 95% confidence interval. Each dot represents an individual participant. Dots above the red line indicate individuals who showed a local attentional benefit from code-switches.

Effects of Code-switching and Attention on Bilinguals' Memory

In our memory analyses, we introduce a three-level factor called *Info Context*, which specifies the language(s) in which the critical information needed to answer a comprehension question was presented. The levels are: (1) in a single-language story, (2) at or near a code-switch in a code-switched story, or (3) far from a code-switch in a code-switched story. This variable differs from the *Language Context* variable used in our attention analyses. While *Language Context* refers to the language environment shortly before an attention probe, *Info Context* focuses on the language in which key information appears in the story. Although the two variables often overlap (as critical information was frequently located near an attention probe), they are not identical.

Bilinguals performed above chance (25 %) on comprehension questions. As hypothesized, Fig. 4. shows that they better remembered information that was presented near a code-switch (M = 64.65 %, SD = 24.57 %) compared to information far from a code-switch (M = 58.38 %, SD = 24.77 %), and compared to information in a single-language story (M = 59.19 %, SD = 24.61 %).

This pattern was supported by an exploratory logistic regression predicting the log(odds) of comprehension question accuracy solely from the *Info Context* factor (Table 3). The aim of this exploratory model was to determine if the context in which information was presented alone explained significant variance in memory for information, before considering how additional variables such as attention to information may further mediate this relationship. The model confirmed that bilinguals remembered information better when it appeared near a code-switch, compared to far from a code-switch, within code-switched stories (p = 0.04). There was no significant difference in memory for information in code-switched vs. single-language stories overall (p = 0.10). These results provide no evidence that memory for information generally increased in code-switched contexts. Instead, there was again evidence for a localized benefit: Memory was better for information that appeared in story sections near a code-switch rather than in single-language sections far from a code-switch.[4] Alongside the attention findings presented above, the data suggest that a code-switching event

[4] In exploratory analyses, we re-ran the attention and memory models from Experiment 1 using an alternative orthogonal coding scheme. This scheme compared content near a code-switch (in a code-switched story) to content not near a code-switch (in either a code-switched or single-language story), as well as comparing single-language content in a code-switched story to single-language content in a single-language story. The results of these analyses (available on OSF) were consistent with the main findings, supporting a local, but not global, effect of code-switches on attention and memory.

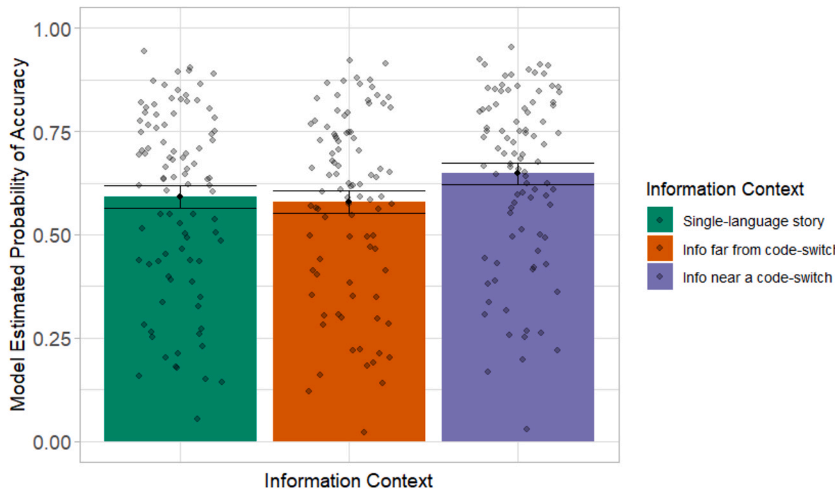

Fig. 4. Bilinguals' Accuracy of Remembering Information. The pre-registered logistic regression model's estimated probability of accurately answering a comprehension question, split by Info Context. Bars represent standard error. Dots indicate individual participants' average estimated accuracy in each language context.

Table 3
Exploratory Regression Model Predicting Bilinguals' Comprehension Question Accuracy from Language Context Alone.

Factor	β	SE	z	p
Intercept	**0.55**	**0.17**	**3.21**	**<0.01**
Info Context: Single-language story vs. Code-switched story	0.12	0.07	1.66	0.10
Info Context: Far vs. Near a code-switch	**0.29**	**0.14**	**2.10**	**0.04**

Note. Model specification: QuestionAccuracy ~ InfoContext + (1 | Participant) + (1 | Question). Info Context was orthogonally coded.

itself is linked to increased memory for information.

Logically, we also expected bilinguals to generally remember information better when they reported paying more attention to it—a factor not included in our exploratory model above. Indeed, as shown in Fig. 5, bilinguals remembered information more accurately when they reported paying more attention to it, regardless of the language in which the information was presented. A pre-registered logistic regression confirmed this relationship, showing that bilinguals' attention significantly predicted memory accuracy ($p < 0.01$; see Table 4). When attention *and* information context were included in the model, the effect of information context on question accuracy was not significant. These findings replicate previous research linking attention during story listening to memory for content (Boudewyn & Carter, 2018) and suggest that improved memory for information near code-switches was driven by increased attention to that information. Additionally, the general pattern also strongly suggests that listeners' subjective reports of attention level are not random or indiscriminate, as they correlate sensibly with objective measures of comprehension (higher reported attention corresponds to better memory, and lower attention to worse memory; see also Boudewyn & Carter, 2018; Mooneyham & Schooler, 2013).

This pre-registered model also included a factor called *Distance of Information from Attention Probe*, which measured the number of intervening sentences between the critical information (needed to answer a comprehension question) and the next attention probe (used as a measure of attention to that information). Including this factor as a covariate allowed us to ensure that any effect of the context in which information was presented (*Info Context*) on memory was not simply due to the proximity of critical information to an attention probe. Although there was a trend for memory to be better for information presented closer to an attention probe, this effect was not statistically significant ($p = 0.06$).

Additionally, we attempted to include code-switching experience (BCSP scores) in this model to determine if code-switching experience interacted with the memory effects; however, the BCSP score variable was removed when the model failed to converge after employing other methods of simplification.

Experiment 1 Discussion

Bilinguals paid more attention to and better remembered code-switched information, clearly contradicting the null account sketched earlier (Account 3). The data also do not support the diverting account (Account 2), which posited that code-switches might direct attention *away* from linguistic messages. Instead, memory was better for information near code-switches, a pattern consistent with the orienting account (Account 1). According to this account, code-switches quickly elicit increases in bilinguals' attention to speech content.

This effect was localized to the code-switching event itself, as attention and memory were not uniformly higher throughout the entire code-switched story but specifically higher near code-switches. At first glance, this might seem inconsistent with findings suggesting that bilinguals generally exhibit greater attentional alertness in mixed-language contexts compared to single-language contexts (Timmer et al., 2021a; Timmer et al., 2021b). However, our attention probes likely measure the degree to which attention is specifically oriented toward speech content, rather than overall alertness. It is also important to note that alerting and orienting effects can be difficult to fully disentangle. Moreover, our study focuses on dynamic, moment-to-moment fluctuations in attention during natural language comprehension (see Salig et al., 2021, for more on this state-based approach), in contrast to prior research that measured sustained attention over longer periods during *non-linguistic* tasks.

Given the evidence for a localized, beneficial orienting effect of code-switches, we consider the possible mechanisms underlying this effect. One explanation is a higher-level process, where listeners draw inferences based on their bilingual experience, while another is a bottom-up process, where the noticeable change in sound patterns at a code-switch automatically grabs attention, independent of linguistic knowledge. If the attentional effect stemmed from the inference process, we might have expected it to interact with participants' code-switching experience, with those having more experience being better equipped to draw such inferences and thus show greater attention increases. However, we did not observe this interaction. The absence of this pattern could reflect a true lack of an effect (as suggested by the Bayes Factor of 0.25 in our exploratory correlation analysis), insufficient statistical power to detect it, or a more categorical distinction between

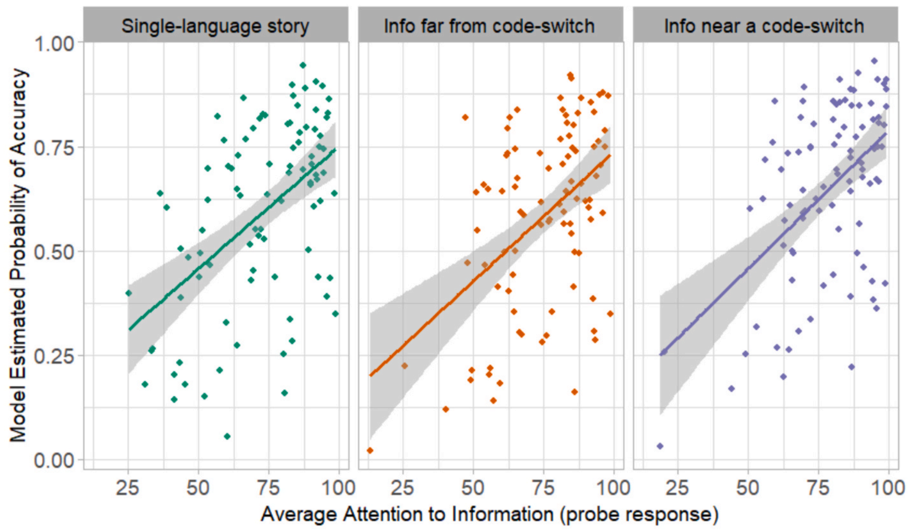

Fig. 5. Bilinguals' Memory Accuracy for and Attention to Relevant Information. Relationship between individuals' average estimated question accuracy and their average self-reported attention to relevant story information interrogated by the question, split by Info Context. The pre-registered logistic regression model's estimated probability of accurately answering comprehension questions was used to calculate individual participants' average estimated accuracy in each Info Context. Gray shading indicates the 95% confidence interval.

Table 4
Pre-Registered Regression Model Predicting Bilinguals' Comprehension Question Accuracy from Language Context and Attention to Information.

Factor	β	SE	z	p
Intercept	**0.54**	**0.16**	**3.32**	**<0.01**
Centered Attention Probe Response	**0.02**	**0.00**	**8.02**	**<0.01**
Info Context: Single-language story vs. Code-switched story	0.04	0.07	0.61	0.54
Info Context: Far vs. Near a code-switch	0.24	0.14	1.73	0.08
Distance of Information from the Attention Probe	−0.04	0.02	−1.88	0.06
Info Context: Single-language vs. Code-switched story * Centered Probe Response	0.00	0.00	0.44	0.66
Info Context: Far vs. Near code-switch * Centered Probe Response	0.00	0.00	0.13	0.90

Note. Model specification: QuestionAccuracy ~ CenteredProbeResponse * InfoContext + InfoDistanceFromProbe + (1 | Participant) + (1 | Question). Info Context was orthogonally coded.

those with and without any code-switching experience, rather than a continuous gradient of experience. We revisit explanations for the lack of an effect of code-switching experience in the General Discussion.

Are our Attention and Memory Effects Simply due to Processing a Less Dominant Language?

Although our data support the orienting account, it is important to consider the characteristics of our participant sample and the language asymmetry of our conditions when interpreting the results. Our bilingual sample seemed slightly English dominant (see AoA and LexTALE values in Table 1; however, note that the LexTALE measures for different languages are not directly comparable) and showed heightened attention to English-to-Spanish code-switches and improved memory for information near code-switches (which was predominantly presented in Spanish). One possible explanation is that our bilingual participants invested more effort into processing, attending to, and/or encoding Spanish information to compensate for it being their less dominant language.

Importantly, however, while our bilingual participants were slightly more English dominant on average, there was variability among them regarding their first language(s), daily exposure to each language, and LexTALE scores. If the observed patterns in our data were solely due to processing the less dominant language rather than the presence of code-switches, we would expect participants with lower Spanish proficiency levels and less experience with Spanish to 1) pay more attention to switches into Spanish, and/or 2) have better memory for Spanish information, compared to participants with higher Spanish proficiency levels and more experience with Spanish.

To address this possibility, we conducted exploratory post-hoc correlational analyses on the results from Experiment 1, focusing on participants' Spanish proficiency and exposure. We found that neither attention to recent code-switches into Spanish nor memory for content presented near code-switches (mostly in Spanish) correlated with participants' measures of Spanish experience or proficiency levels (Spanish LexTALE scores, Spanish AoA, and percent of daily exposure in Spanish; $|r|s \leq 0.11$, $ps \geq 0.30$). Additionally, the magnitude of the attention effect (defined as attention near code-switches minus attention far from code-switches) showed no significant correlation with Spanish LexTALE scores, Spanish AoA, or percent of daily exposure in Spanish ($|r|s \leq 0.18$, $ps \geq 0.09$). We also plotted the magnitude of the attention effect based on participants' first language(s) and observed that the effect was present across different first languages (plot available on OSF).

Although the null results limit strong conclusions, the exploratory correlation analyses do not support the idea that the attention and memory effects observed in Experiment 1 stem from increased effort in processing information in a less proficient, weaker, or less frequently encountered language.[5] The absence of correlations between the attention effect and individual language factors aligns with findings from Tomić and Valdés Kroff (2022), who reported that bilinguals anticipated lower frequency referents after encountering code-switches, independent of their language dominance. This finding held true despite the code-switches occurring in one direction within a contextually dominant language (in their case, Spanish).

Our explanation for the observed patterns in this study is that the code-switches, rather than the presence of the less dominant language, elicit the increase in attention to and memory for information among

[5] Bayes Factors for these exploratory correlational analyses ranged from 0.24 to 0.95, providing some support for the null hypothesis.

bilingual participants, as we observe the effects across participants with varying levels of proficiency and experiences. It is important to note that *all* bilingual participants in our study were proficient in both languages as per our participation requirements. Therefore, the lack of correlations between Spanish experience and attention/memory results is not surprising; rather, it simply suggests that our attention/memory results are not solely due to processing a less dominant language. Nonetheless, future research should continue to investigate the role of dominance effects in modulating attention and memory while interpreting code-switches.

Disentangling Knowledge-driven vs. Signal-change Mechanisms

Our findings from Experiment 1 suggest that code-switches draw bilingual listeners' attention in ways consistent with an orienting account. However, the mechanisms underlying this attentional effect remain unclear. Are code-switches attention-orienting due to the perceptual salience of the switch itself (a purely bottom-up effect), or does the effect stem from bilinguals' linguistic experience and their ability to infer the relevance of the switched information (a knowledge- and inference-based process)?

One way to explore this question is to investigate if code-switches orient attention even for listeners without relevant linguistic experience. For example, if bilinguals' heightened attention near code-switches is primarily salience-driven, then monolingual listeners—despite lacking bilingual language experience—should also show an attentional effect at code-switches. However, if the effect is knowledge-driven, based on bilinguals' ability to interpret a switch as a cue to focus on upcoming information, then monolinguals should not show the same attentional pattern.

To test this, in Experiment 2, English-speaking monolinguals completed the same story-listening task as the bilinguals in Experiment 1, listening to one story entirely in English and another that included English-to-Spanish code-switches, periodically reporting their attention levels. Monolinguals could still follow most of the narrative since only about 5 % of the code-switched story was in Spanish. Testing monolinguals allowed us to isolate the potential influence of bottom-up (signal-driven) attentional effects of code-switches, independent of bilingual experience. While comparing bilinguals with high versus low code-switching experience could offer another way to disentangle salience- and experience-driven effects, Experiment 1 found no significant relationship between bilinguals' code-switching experience and the attentional effect of code-switches, suggesting that such effects may be small or difficult to detect. Additionally, recruiting bilinguals with minimal code-switching experience is challenging in the U.S., as illustrated by the mere six participants in Experiment 1 who reported never code-switching.

Although effects on attention were the primary focus of Experiment 2, we also included comprehension questions to assess memory performance for consistency with Experiment 1.

Experiment 2 Method

The method of Experiment 2 was identical to that of Experiment 1 with a few exceptions. First, although all participants completed the study using the same online platform (PCIbex), Experiment 2 participants were recruited from the University of Maryland's study pool and received course credit for their participation, as opposed to Experiment 1 participants who were recruited through Prolific and received payment. Second, we specifically recruited English-speaking monolinguals who confirmed that English was their first and only language, without significant experience in other languages. Thus, participants did not need to complete a qualifying survey to assess language proficiency. Third, we added language history questions at the end of the study to ascertain if participants had any notable experience with other languages.

As in Experiment 1, participants could be assigned to one of four lists: Story1CodeSwitched-Story2SingleLanguage (n = 19), Story1SingleLanguage-Story2CodeSwitched (n = 24), Story2CodeSwitched-Story1SingleLanguage (n = 20), and Story2SingleLanguage-Story1CodeSwitched (n = 23). In the instructions to the experiment, participants were encouraged to pay attention to the stories, even if they encountered parts in a language they did not understand.

Although Experiment 2 was not pre-registered, we followed the same data collection and analysis procedures as in the pre-registered Experiment 1, with only minor changes as described below.

Participants

A total of 110 monolinguals participated in Experiment 2. The same exclusion criteria pre-registered for Experiment 1 were applied, resulting in the exclusion of 24 participants for failing to respond to 25 or more of the 49 attention probes, failing 2 or more of the 4 engagement checks, and/or giving the same response to all attention probes. Eighty-six participants were included in the final analyses (49 women, 31 men, and 6 who did not report gender). The included participants had a mean age of 19.14 years (SD = 1.18).

Although all participants identified as being functionally monolingual, they reported varying experiences with other languages, including Spanish. Fifty-one participants reported having learned or attempted to learn Spanish at some point: 21 reported one year or less of Spanish experience, 19 reported two or three years, 7 reported four or five years, and 4 reported more than five years. Most Spanish experience was in the form of formal classroom second language learning that occurred between elementary and high school, which can be highly variable in the U.S. Overall, responses indicated minimal (and not current) experience learning Spanish in a classroom environment. All 86 participants reported that they had never read either of the stories used in the study.

Experiment 2 Results

In Experiment 1, we used orthogonal coding in our regression models to compare performance in the English-only story vs. the code-switched story as a whole, and to compare performance in the code-switched sections vs. single-language sections of the code-switched story. However, in Experiment 2, it was more appropriate to use new orthogonal coding to enable more meaningful comparisons. Orthogonal coding in Experiment 2 allowed for comparisons between performance in single-language English sections (in either the code-switched or English-only story) vs. in code-switched sections, and between performance in English sections of a code-switched story vs. English sections of a single-language story. We made this change in consideration of the results of Experiment 1, where attention increased shortly after a code-switch but not throughout an entire code-switched story. Additionally, the participants in Experiment 2 were monolinguals, which influenced the choice of coding approach. The new orthogonal coding allowed us to isolate the effect of code-switches and then assess whether the presence of code-switches in a story affected monolinguals' processing of information presented in English (their known language). The models with the new orthogonal coding are reported here but Experiment 2 models using the original orthogonal coding (identical to Experiment 1′s coding) are also available on OSF.[6]

[6] The pattern of Experiment 2 results did not change after removing 16 participants who reported an attention disorder or medication. Similarly, the patterns did not change when we excluded 21 participants who scored below chance (<25%) on the comprehension questions.

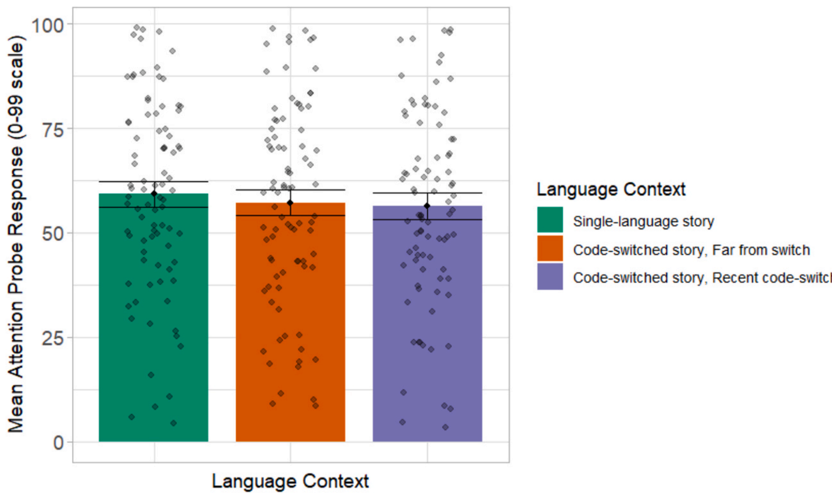

Fig. 6. Monolinguals' Attention Responses by Language Context. Mean self-reported attention, split by language context. Bars represent standard error. Dots indicate individual participants' average probe response in each language context. Importantly, as described in the text, there was no significant difference in attention to English-only content when it appeared in a single-language story versus when it appeared far from a code-switch in a code-switched story.

Table 5
Regression Model Predicting Monolinguals' Attention from Language Context.

Factor	β	SE	t	p
Intercept	−0.40	2.28	−0.17	0.86
Language Context: Near a code-switch vs. Single-language context	**3.48**	**1.73**	**2.01**	**<0.05**
Language Context: Single-language section in Code-switched story vs. in Single-language story	0.99	2.25	0.44	0.66

Note. Model specification: CenteredProbeResponse ~ LanguageContext + (LanguageContext | Participant) + (1 | Probe). Language Context was orthogonally coded.

Effects of Code-switching on Monolinguals' Attention

As shown in Fig. 6, monolinguals reported higher attention in an English-only story (M = 59.25, SD = 22.88) and when probed in a single-language stretch of a code-switched story (far from a code-switch, M = 57.19, SD = 23.79) compared to when probed near a code-switch (M = 56.18, SD = 23.07), which was confirmed by our regression model (Table 5; $p < 0.05$, $\eta_p^2 = 0.04$). This finding suggests that monolinguals did not experience the same attentional boost from code-switches as bilinguals, indicating that the saliency of the language change alone is unlikely to fully account for the increased attention observed in bilinguals in Experiment 1.

Additionally, there was no significant difference in attention to single-language content that occurred in a code-switched story (far from a code-switch) compared to in a single-language story ($p = 0.66$). This suggests that the general presence of code-switches did not disrupt monolinguals' attention to information in their known language (English).

Cross-Experiment Analysis of Language Context and Attention. We also conducted a model incorporating attention data from both experiments, revealing significant interactions between Language Context and Experiment (Table 6; ps < 0.05, $\eta_p^2 = 0.08$). This analysis indicates that bilingual participants in Experiment 1 exhibited distinct attentional responses to the language contexts compared to monolinguals in Experiment 2. The differing patterns suggest that the presence of code-switching influenced attention differently for bilinguals versus monolinguals, underscoring the impact of bilingual experience on attentional processes during language comprehension.

Table 6
Exploratory Regression Model Predicting Attention from Language Context and Experiment.

Factor	β	SE	t	p
Intercept	**8.56**	**1.99**	**4.31**	**<0.01**
Language Context: Single-language story vs. Code-switched story	2.59	1.81	1.43	0.15
Language Context: Far vs. Near a code-switch	**2.76**	**1.24**	**2.22**	**0.03**
Experiment: Exp 1 (bilingual) vs. Exp 2 (monolingual)	**−17.77**	**2.76**	**−6.43**	**<0.01**
Language Context: Single-language vs. Code-switched story * Experiment	**−5.14**	**2.60**	**−1.98**	**<0.05**
Language Context: Far vs. Near code-switch * Experiment	**−5.72**	**1.62**	**−3.54**	**<0.01**

Note. Model specification: CenteredProbeResponse ~ LanguageContext * Experiment + (LanguageContext | Participant) + (LanguageContext | Probe). Language Context was orthogonally coded, using the orthogonal coding scheme from Experiment 1 which allowed for comparisons between code-switched vs. single-language stories overall and between code-switched vs. single-language sections of a code-switched story.

Effects of Code-switching and Attention on Monolinguals' Memory

In Experiment 2, our primary focus was to investigate whether monolinguals, like bilinguals, exhibited an attentional increase in response to code-switches. However, we also report the memory results for completeness. Given that monolinguals cannot comprehend the content presented in Spanish, their unfamiliar language, we hypothesized that code-switches would not enhance their memory for information around these switches.

Monolinguals performed above chance (25 %) on comprehension questions. Our logistic regression analysis revealed that monolinguals demonstrated significantly better memory for English-only information (from either the code-switched or single-language story) compared to code-switched information (Table 7; $p < 0.01$). As shown in Fig. 7, this difference appeared to be primarily driven by monolinguals' stronger memory for information in the English-only story (M = 47.49 %, SD = 24.69 %), as their memory performance was numerically comparable between single-language material within the code-switched story (far from a code-switch: M = 42.31 %, SD = 27.44 %) and material near a code-switch (M = 42.91 %, SD = 26.58 %). However, there was no statistically significant difference in memory for English information presented in a single-language story versus English information in a code-switched story (far from any code-switch; $p = 0.10$). This null

Table 7
Logistic Regression Model Predicting Monolinguals' Comprehension Question Accuracy from Language Context and Attention to Information.

Factor	β	SE	z	p
Intercept	**−0.41**	**0.16**	**−2.57**	**0.01**
Centered Attention Probe Response	**0.02**	**0.00**	**7.76**	**<0.01**
Info Context: Near a code-switch vs. Single-language context	**0.45**	**0.13**	**3.54**	**<0.01**
Info Context: English information in Code-switched story vs. in Single-language story	0.13	0.08	1.66	0.10
Distance of Information from the Attention Probe	**−0.04**	**0.02**	**−2.47**	**0.01**
Info Context: Near code-switch vs. Single-language context * Centered Probe Response	0.00	0.00	1.07	0.28
Info Context: English info in Code-switched story vs. in Single-language story * Centered Probe Response	0.00	0.00	−0.57	0.57

Note. Model specification: QuestionAccuracy ~ CenteredProbeResponse * InfoContext + InfoDistanceFromProbe + (CenteredProbeResponse | Participant) + (1 | Question). Info Context was orthogonally coded.

finding aligns with the attention results, suggesting that the presence of code-switches in a story did not impair monolinguals' ability to process and retain information in the language that they understood.

Although code-switches did not enhance monolinguals' memory (as expected), the monolinguals still performed above chance on average on comprehension questions related to code-switched information ($M = 42.91$ %, where chance is 25 %). Therefore, it is plausible that monolinguals were able to extract some information near code-switches by leveraging story context, proper nouns, and limited prior exposure to Spanish.

Importantly, our model also confirmed that monolinguals demonstrated a link between attention and memory: They were more likely to accurately remember information that they had paid more attention to ($p < 0.01$; see Fig. 8). Further, this relationship did not interact with language context ($ps \geq 0.28$), suggesting that the attention-memory link held across all language contexts.

There was also a significant effect of the distance between the critical information and the attention probe ($p = 0.01$). Specifically, participants were more likely to accurately remember information needed to answer a comprehension question if it occurred closer to an attention probe. This suggests that the study design may have enhanced memory for information presented shortly before attention probes. While this factor was included in the model to account for its contribution to memory variation, it is important to note that the other effects discussed emerged independently of this factor.

Experiment 2 Discussion

Experiment 2 aimed to compare the effects of code-switching on attention between bilinguals (the focus of Experiment 1) and monolinguals. By including monolingual participants, the study sought to determine whether the attentional benefits observed in bilinguals were unique to bilingual language processing or if they reflected a more general stimulus-driven phenomenon that could also be observed in monolinguals. The bottom-up, stimulus-driven hypothesis posits that the salient change in sound patterns at a code-switch may automatically orient attention, regardless of linguistic knowledge, thereby increasing attention in both bilinguals and monolinguals. This possibility was explored by assessing whether monolinguals also exhibited increased attention after hearing a code-switch, despite lacking the same language experience as bilinguals.

The monolinguals in Experiment 2 did not show an increase in attention to the story shortly after a code-switch, unlike the bilinguals in Experiment 1. In fact, the monolinguals showed the opposite pattern—with greater attention to information that was *not* near a code-switch. This finding suggests that the mere presence of a code-switch is not adequate to elicit an attentional increase, at least not in monolingual listeners. In the General Discussion, we consider what factor(s) may have caused bilinguals' increased attention to and improved memory for code-switched information in Experiment 1. Here, we note that the contrasting results in Experiment 2 suggest that a bottom-up process related to the saliency of the language change was not the sole driver of Experiment 1's results. Thus, the findings in Experiment 2 imply that bilinguals' increased attention following a code-switch may be influenced by higher-level cognitive processes, such as recognizing the importance of the information conveyed by a language switch.

Crucially, Experiment 2 replicated the link between attention and memory, with monolinguals remembering information better that they had attended to more, across all language contexts. This attention-memory link indicates that the attention probes were measuring attention as intended, despite the peculiar task of asking monolinguals to listen to a story that contained code-switches. Despite the unusual task, English-speaking monolinguals seemed equally capable of attending to and remembering English information whether it was presented in a

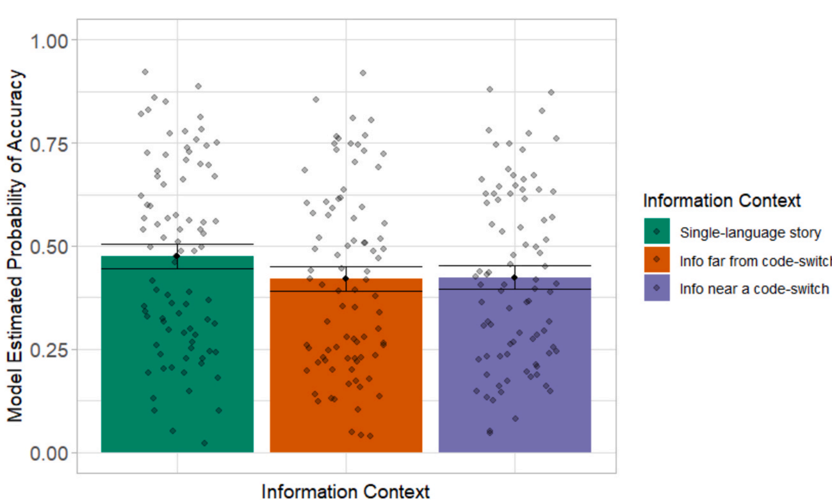

Fig. 7. Monolinguals' Accuracy of Remembering Information. The logistic regression model's estimated probability of accurately answering a comprehension question, split by Information Context. Bars represent standard error. Dots indicate individual participants' average estimated accuracy in each language context. Notably, as described in the text, there was no statistically significant difference in memory for English information presented in a single-language story versus English information far from a code-switch in a code-switched story.

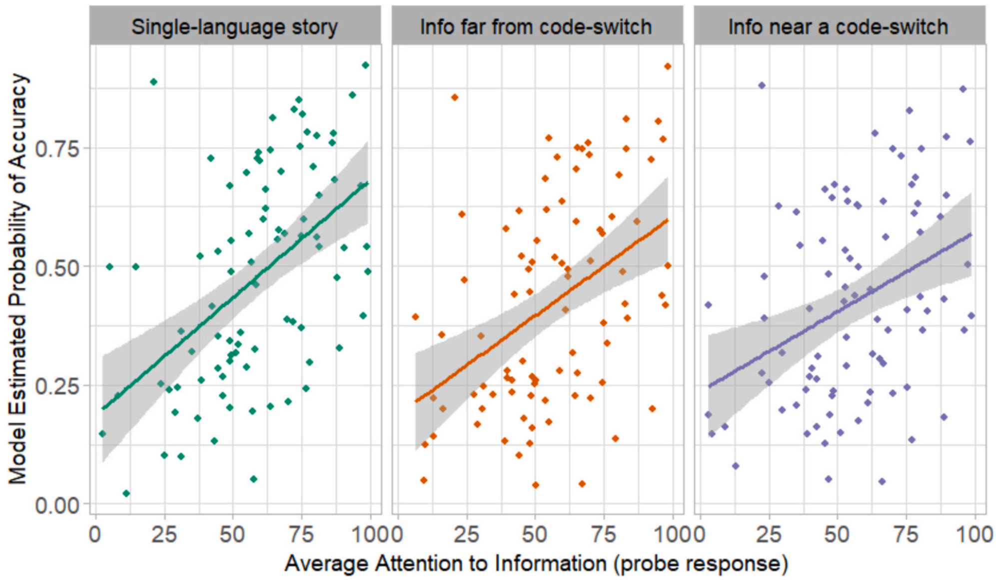

Fig. 8. Monolinguals' Memory Accuracy for and Attention to Relevant Information. Relationship between individuals' average estimated question accuracy and their average self-reported attention to relevant story information interrogated by the question, split by Information Context. The logistic regression model's estimated probability of accurately answering comprehension questions was used to calculate individual participants' average estimated accuracy in each context. Gray shading indicates the 95% confidence interval.

single-language story or a code-switched story, suggesting that the mere presence of code-switches was not detrimental to their processing of information presented in their known language. Monolinguals also performed above chance in remembering information presented near a code-switch into Spanish, suggesting that they were able to leverage context clues to extract some information in code-switched contexts.

It is worth noting that participants in Experiment 2 reported lower attention overall and had lower comprehension question accuracy compared to the bilingual participants in Experiment 1. The lower overall performance emerged even for the single-language English story, suggesting that this difference between experiments likely stems from the recruitment and compensation methods: Experiment 1 participants were recruited via Prolific and compensated monetarily, while Experiment 2 participants were recruited from a university participant pool and received class credit. Despite these methodological differences, a key finding—namely, the link between attention and memory—remained consistent across both experiments. This suggests that a core mechanism under investigation, the relationship between attention and memory during story listening, is robust and not confounded by recruitment differences. Importantly, comprehension accuracy in Experiment 2 remained above chance, affirming that participants were meaningfully engaged in the task and allowing us to interpret the results with confidence.

It is also worth addressing the linguistic profiles of the monolingual participants. Although one limitation of Experiment 2 is the lack of language proficiency measures, the participants appeared to be monolingual. While some reported prior exposure to Spanish, primarily through classroom experiences, they largely reported no current exposure to other languages and seemed functionally monolingual. Yet, for the code-switched story, monolingual participants exhibited similar memory performance for both single-language information far from code-switches and information near code-switches. How, then, were monolinguals able to accurately answer comprehension questions about information near or in a switch to Spanish? Recall that "near code-switch" information sometimes appeared in the English portion of a code-switched sentence or included recognizable proper nouns. Additionally, since 95 % of the code-switched story was in English, monolingual participants could have used context clues to infer the correct answer for some questions. These factors likely explain their ability to correctly answer such questions despite not understanding the Spanish segments of the stories.

General Discussion

We tested the hypothesis that code-switches enhance bilingual listeners' attention to and memory for information presented around the switch. Experiment 1 yielded two key findings: First, during a natural story-listening task, bilinguals reported greater attention following recent code-switches compared to single-language content. Second, this attentional increase was associated with improved memory for code-switched information. In contrast, Experiment 2 showed that monolinguals did not exhibit similar attentional increases after code-switches, indicating that the beneficial effects observed in bilinguals were largely influenced by their bilingual language experience.

Across both experiments, information that received higher attention was remembered more accurately, supporting the reliability of the self-reported attention probes in measuring attention to linguistic messages.

Among the three proposed accounts in the Introduction for how code-switches might affect bilinguals' attention, the results align with the orienting account. Specifically, the findings indicate that code-switches directed bilinguals' attention toward the linguistic content, leading to heightened attention and improved memory for information near the switch.

Implications for State-Based Approaches in Bilingual Language Processing

Our study adopts a state-based approach to the study of bilingual language processing, contrasting with traditional trait-based investigations that primarily examine enduring differences between groups (see Salig et al., 2021, for discussion). While prior research has explored potential global differences in attentional traits between bilinguals and monolinguals (e.g., Bialystok & Craik, 2022; Chung-Fat-Yim et al., 2023; deMeurisse & Kaan, 2023; Grundy & Bialystok, 2018), we focus on attentional *states*—moment-to-moment fluctuations in cognitive operations that occur within individuals during language processing.

By examining bilinguals' responses to code-switches, we demonstrate how specific linguistic cues dynamically alter attentional states, providing a more granular perspective on the cognitive mechanisms at play. This approach highlights the fluid nature of attention in bilingual language comprehension, showing that cognitive processes are not static but adapt in real time to the demands of the linguistic input.

This complementary perspective is critical, as it shifts the focus from stable, group-level differences to the dynamic interplay between language cues like code-switching and cognitive operations within individuals. By capturing these transient cognitive states, our findings shed light on how bilinguals leverage their linguistic experience to navigate complex language environments, offering a nuanced understanding of the real-time dynamics of bilingual language processing.

Which Aspect of Attention is Affected by Code-switches?

Our results indicate that the orienting aspect of attention is dynamically influenced by code-switches during bilingual comprehension. Upon encountering a code-switch, bilingual listeners prioritized processing the linguistic information associated with the switch over other content, resulting in better memory for the code-switched information.

This finding contrasts with previous studies that primarily examined enhanced attentional *alerting* for bilinguals in mixed-language contexts without observing significant effects on attentional *orienting*. Timmer and colleagues investigated bilinguals' engagement of alerting, orienting, and executive control using the Attentional Network Task (ANT) and electroencephalography (EEG) in single- and mixed-language contexts (Timmer et al., 2021a; Timmer et al., 2021b). Their EEG findings revealed heightened alerting and executive control in mixed-language contexts, but behavioral measures did not show differences across language conditions. This methodological focus contrasts with our study, which assessed real-time attentional fluctuations during naturalistic language comprehension. Whereas Timmer et al. examined global readiness (alerting) during a non-linguistic task, our work focused on *localized orienting* responses to code-switches during speech, providing a more context-specific perspective on bilingual attention.

Building on this distinction, prior research has used isolated words in non-linguistic tasks to investigate general alerting effects in mixed-language contexts. In contrast, our research examines how bilinguals flexibly adjust their attention during narrative story comprehension. We found no evidence of overall heightened attention throughout entire code-switched stories compared to single-language stories. Instead, our findings highlight that bilinguals adapt their attention dynamically, sharpening their focus specifically at the moment of a code-switch. This localized effect underscores the role of code-switches in guiding attentional orienting rather than inducing a global alerting state.

While previous research has suggested general alerting effects in mixed-language contexts, our work uniquely reveals how code-switches elicit momentary, targeted shifts in attention. Future research should further disentangle the mechanisms underlying attentional alerting and orienting in bilingual processing, exploring how these processes vary across different tasks and timescales.

Exploring the Source of Bilinguals' Increased Attention: Knowledge-driven or Salient Signal-change?

The orienting effect may stem from a knowledge-driven process, where listeners infer meaning from a code-switch (what is the speaker trying to communicate?), or from a bottom-up, stimulus-driven process, where a phonological change directs attention to the message content.

According to the knowledge-based inference view, code-switches boost attention because listeners have learned through experience to infer that code-switches contain pragmatic and/or sentential cues to comprehension that have communicative value, prompting them to increase their attention to collect crucial information. One might therefore expect bilinguals with more code-switching experience to demonstrate greater attentional benefits from code-switches. However, we did not observe this pattern. Furthermore, our exploratory correlation analysis found no evidence that greater code-switching experience was associated with larger attentional benefits from code-switches. In fact, the Bayes Factor of 0.25 provides some support for the null hypothesis. Given this lack of evidence for the inference view, we further consider the phonological change view below. Alternatively, it is possible that only a minimal amount of code-switching experience is necessary to draw such inferences, and our participants—who had moderate code-switching experience on average—may have already surpassed this threshold (see Table 1). Future studies could test this hypothesis by recruiting bilinguals from communities where code-switching is uncommon (e.g., Granada, Spain; Beatty-Martínez et al., 2020b), as such settings could provide clearer insight into the role of varying code-switching experience. Additionally, exposing bilinguals to code-switches in unfamiliar languages might help disentangle whether the observed effects are specific to bilinguals' linguistic environments and cultural norms or reflect a broader, language-independent orienting response to switching. By addressing these questions, future research could refine our understanding of the mechanisms underlying the attention boost observed in response to code-switches.

According to the stimulus-driven phonological change view, code-switches boost attention because the saliency of the switch between languages orients listeners' attention to speech content. That is, the switch from one phonological system to another (or, in the case of monolinguals, the shift away from a familiar phonological system) drives the attentional effect from the bottom up. However, in Experiment 2, monolinguals did not demonstrate an attentional increase upon hearing a code-switch (and in fact, demonstrated less attention to the story). This finding indicates that the salient change in sound patterns associated with code-switching was not sufficient to cause bottom-up orienting of attention to the speech signal. If it were, one would expect both bilinguals and monolinguals to show increased attention. Instead, the findings tentatively suggest that bilinguals' increased attention and memory might be related to higher-level inferences that they draw about the communicative intent of code-switches.

It may seem obvious that monolinguals would not pay attention to code-switches, as they would not understand the switch into a language they do not know. However, this is precisely the point of interest. Bilingual individuals, upon hearing a code-switch, may interpret it as a signal that the upcoming information is intended for them or is particularly relevant to attend to, prompting them to tune in and focus on the message. In contrast, monolinguals do not exhibit increased attention because there is little message-level content they could extract from the switch into Spanish. If the sole driver of increased attention were the phonological change associated with code-switching, rather than an inference process, then we would expect (and observe) a different pattern. Specifically, we would expect monolinguals to also show increased attention. In this sense, their attention results provide a valuable contrast, helping to pinpoint the underlying mechanism responsible for the attention boost observed in our findings.

Minimally, if the phonological change itself cannot fully explain the findings in Experiment 1, this suggests that bilinguals may be engaging in cognitive processes beyond just perceiving and attending to the shift in sound patterns. This notion is supported by recent work in bilingual sentence processing, which demonstrates that bilinguals are sensitive to the pragmatic contexts in which code-switches are likely to occur. For example, Tomić and Valdés Kroff found that bilinguals anticipate low-frequency referents (2022) or emotionally negative stimuli (2021) after hearing a code-switch. Similarly, bilinguals incur a processing cost, as shown by an increased late positive event-related potential (ERP) effect, when encountering code-switches in the presence of monolinguals (Kaan et al., 2020). These findings suggest that bilinguals track information about the contexts under which code-switching occurs, including the interactional environment and instances when a bilingual speaker may refer to something unexpected. Our data indicate that code-switches similarly lead to a shift in attention. Taken together with these prior studies, our finding of an attentional orienting effect of code-switches may be the consequence of bilinguals' knowledge of the pragmatic contexts and communicative functions that code-switching serves. These patterns undermine a solely stimulus-driven account of our effects and emphasize the significance of linguistic experience in influencing the attention and memory effects of code-switches in bilinguals.

It is possible that bilinguals' prior experience with multiple languages and/or with code-switches modifies their response to the phonological change at a code-switch, allowing the shift in sound patterns to orient their attention, while it does not do so for monolinguals. If so, we might expect bilinguals with different levels of code-switching experience to have different sensitives to phonological changes, which should lead to different attentional effects. Again, however, we observed no evidence for such an interaction in our study, as individual differences in code-switching experience did not impact the attentional boost that code-switches generated. This lack of interaction could be because phonological changes affect all bilingual listeners in a similar way. Regardless, the results of Experiment 2 make it clear that a bottom-up, stimulus-driven process alone is not sufficient for code-switches to alter attention in the absence of bilingual experience.

Overall, our data provide novel psycholinguistic evidence that code-switches enhance bilinguals' language comprehension by orienting attention to the message of spoken input. The contrasting attention data patterns exhibited by monolinguals in Experiment 2 challenges a purely stimulus-driven account, suggesting instead that bilingual knowledge is a crucial factor in modulating attention when encountering a code switch.

One intriguing avenue for future research is the developmental trajectory of experience in bilingual language processing. It is plausible that young bilingual children may initially exhibit attentional effects in response to the phonological change in a code-switch before fully developing sensitivity to the intended pragmatic meaning. Understanding the emergence and development of this knowledge in early childhood could provide valuable insights into the cognitive mechanisms underlying the comprehension of code-switches and its impact on attention and memory in bilingual individuals.

Comparing the Costs and Benefits of Code-switching

We consider our study a crucial initial step toward elucidating the effects of code-switches on bilinguals' language comprehension and learning, moving beyond the field's conventional emphasis on switch *costs*. Indeed, given the prevalent focus on switch costs in psycholinguistic research, even subtle effects in the opposite direction can be impactful. Our study challenges the standard interpretation that differences in processing code-switched versus single-language sentences solely reflect processing difficulties.

Specifically, much psycholinguistic research has focused on switch costs during bilingual sentence processing (e.g., Bultena et al., 2015; Litcofsky & Van Hell, 2017), often framing code-switching as advantageous for speakers but costly for listeners (e.g., Beatty-Martínez et al., 2020a; cf. Tomić & Valdés Kroff, 2021). While we acknowledge the presence of switch costs during moment-by-moment comprehension, our results also indicate that—on a broader timescale—hearing a code switch can be beneficial. We propose that code-switches enhance bilinguals' attention when encountered, and this attentional orientation persists long enough to influence processing over seconds at least, enabling crucial information to be encoded by the listener. This timescale clearly stands apart from the millisecond scale typical in real-time processing studies assessing switch costs.

Further, the attentional benefit we found has downstream effects on an even longer timescale, as demonstrated by improved memory for information near a code-switch that had been heard up to 30 minutes earlier. These findings challenge a deficit-focused perspective on code-switching, which has often emphasized the processing costs associated with encountering a switch in isolated sentences, where each trial is disconnected from the next. Instead, we propose that code-switches trigger an attentional shift toward the signal, which—while momentarily slowing processing—ultimately enhances memory and learning. This benefit may be especially pronounced in contexts with richer semantic content, such as conversations or narratives (as investigated here), where listeners have more opportunities to encode meaningful information than in experiments with decontextualized, trial-by-trial stimuli.

A fruitful area of future research will be to explore whether the well-established switch "costs" during comprehension might index operations related to deploying attention and memory encoding. For example, does the momentary delay associated with processing a code-switch reflect a mechanism that ultimately yields longer-term benefits in memory and learning? By linking switch costs to potential advantages, future studies could further illuminate the dynamic interplay between processing and memory in bilingual language use.

Limitations, Broader Impacts, and Closing Remarks

The current study offers an alternate perspective on the cognitive effects of code-switching, suggesting that bilinguals benefit from hearing code-switches. We propose that one mechanism for this benefit is that a code-switch directs bilinguals' attention to the message, thereby enhancing their ability to encode and remember information. This model helps explain why code-switches do not always hinder communication and why bilinguals in certain speech communities frequently engage in code-switching practices (see Beatty-Martínez et al., 2018; Valdés Kroff & Dussias, 2023).

While our work bridges the experimental and sociolinguistic study of code-switching—aligning with the latter's recognition of code-switching as a beneficial discourse strategy (Bhatt & Bolonyai, 2011; Gumperz, 1982)—we acknowledge that our focus on a single switch direction (English to Spanish) represents an experimental constraint aimed at balancing ecological validity with controlled comparison (see Kaan et al., 2020 for a similar design choice). Although code-switch directionality varies across bilingual communities, even within the U.S., our decision was guided by norming data showing that this switch direction was natural and familiar for our participants. This approach ensured ecological validity for our sample while allowing for a controlled investigation of the attentional effects of code-switches. Our remote study recruited participants across the U.S., reflecting bilinguals with diverse code-switching experiences and community-supported bilingual practices. Thus, the observed effects of code-switches on attention and memory may underestimate the true effect size, given our focus on a single switch direction. Future research should explore whether these attentional orienting effects generalize to switches in the reverse direction (Spanish to English) or across bilingual communities with differing patterns of code-switching or minimal exposure to it. While we focused on one switch direction, the observed mechanism—localized attentional orienting—is likely robust across diverse switching contexts.

Overall, our findings argue for a deeper examination of the mechanisms sustaining bilingual communities' acceptance and prevalence of code-switching practices. They demonstrate how code-switching enhances communication in bilingual discourse while opening avenues for further exploration. Our study lays the groundwork for systematically investigating how various factors modulate attention and memory during code-switching. These include linguistic variables (e.g., switch direction, type, and morphosyntactic juncture), individual factors (e.g., language dominance and code-switching experience), and pragmatic considerations (e.g., message content and conversational partner).

Zooming out, humans' ability to attend to and remember information is a crucial skill, especially in educational settings where the goal is to learn new material. This study replicates previous findings showing that increased attention while listening is linked to better memory for information later (Boudewyn & Carter, 2018; Smallwood et al., 2008). Importantly, we extend this effect by demonstrating the same relationship in bilingual code-switching contexts. This discovery adds to the growing body of evidence that mixed-language learning environments do not create undesirable outcomes (Antón et al., 2016; Antón et al., 2020; Blair & Morini, 2023; Lin, 2013; Pérez & Duñabeitia, 2019), contrasting with decades of policies that favor single-language, monolingual-oriented classrooms.

Actually, our findings provide evidence that mixed-language contexts can be beneficial for bilinguals: Code-switching can *increase* bilingual listeners' attention to and their later memory for material near the switch. We therefore suggest that naturalistic code-switching may benefit bilinguals' learning, although additional research is needed in this area. While this suggestion is not new in educational or sociolinguistic fields (Cashman, 2005; Cook, 2001; Gardner-Chloros, 2009; Gumperz, 1982; Lin, 2013), there has been little psycholinguistic and cognitive evidence to support it—a gap our study begins to fill (see also Kaushanskaya et al., 2022; Read et al., 2021; Tomić & Valdés Kroff, 2022). It is also worth noting that in our Experiment 2, monolinguals' attention to and memory for information in their known language was not negatively affected by the presence of code-switches elsewhere in the story. This suggests that allowing more flexible use of multiple languages may enhance bilinguals' learning without compromising monolinguals' learning if information is available in the monolinguals' known language. We recommend further research in this area to establish an evidence-based approach for supporting the learning of all students.

The attentional and memory benefits observed in bilinguals upon hearing a code-switch represent initial evidence of benefits rather than costs and warrant further exploration. Future work should examine how code-switches impact learning in various contexts, including in tasks that closely approximate classroom learning, and for learners of different ages. Meanwhile, we join others in spotlighting the potential advantages that mixing languages could offer in bilingual comprehension. Specifically, hearing naturalistic code-switches may help guide bilingual listeners to collect and remember critical information.

CRediT authorship contribution statement

Lauren K. Salig: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization. **Jorge R. Valdés Kroff:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization. **L. Robert Slevc:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization. **Jared M. Novick:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization.

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Data availability

The materials, analysis scripts, and data for participants who consented to data sharing are available on OSF.

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