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The rise of aspiration in Polish. How passive contact with a language can alter speakers' L1.

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ABSTRACT

This paper is a production and perception study exploring the effect of exposure to English media on aspiration in Polish. Standard Polish does not have aspiration, but previous studies on that topic showed that a group of native Polish speakers, who were proficient in English and used it in a work setting every day, showed longer VOTs in voiceless plosives. The current study revisits that topic but with a slightly different approach. The focus is on sound change in L1 dominant environment, following the rise of English spoken media in Poland in the recent years. Other studies showed that speakers' L1 could change in L1 dominant environment and even without L2 knowledge. The homogenous environment people are in is key in that process, thus the speculation if even exposure to English media could lead to longer VOTs in Polish. To test that, a questionnaire followed by a production and perception experiment was carried out. The hypothesis was that Polish speakers, who have been exposed to more English spoken media, would produce longer VOTs but they would do so unknowingly, as they would not hear the difference between aspirated and non-aspirated plosives. The results were surprising on many levels, namely while they showed significance, they were also contradictory with some assumptions based on the previous literature and phonetic universals.

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1. INTRODUCTION

Each language in the world, whether it is spoken, signed or even computer language, has a fixed set of characteristics specific to it. Spoken languages are unique for having phonetic properties and aspiration is one of them. The phenomenon of aspiration in phonetics is the puff of air that accompanies a speech sound and can be measured by calculating the Voice Onset Time (VOT), that is the time between the release of a plosive and the start of voicing of the phoneme that follows it. While English is a language that is known for having aspirated plosives, standard Polish is not. But what would happen to Polish sound system, and this lack of aspiration, if native Polish speakers were passively exposed to a vast amount of English?

This study is a production and perception study that will explore the topic of possible aspiration in Polish by measuring the VOT length in voiceless plosives among native Polish speakers living in L1 dominant environment. Its focus is on the effect of passive contact with a language, here that is English spoken media such as movies with subtitles instead of dubbing, or short form video content available on social media, on aspiration in Polish. It also explores if native Polish speakers are able to differentiate between aspirated and non-aspirated speech sounds, similar to Mandarin Chinese speakers. The project delves into the topics of the attitudes of Polish speakers towards English as the new-age language of the modern Europe, as well as the effects of interaction between speakers' L1 and L2 across languages such as Brazilian Portuguese, Russian, and Hebrew. It will also touch on topics of language change and attrition and will focus on testing assumptions based on phonetic universals and speech paradigms.

2. BACKGROUND

2.1. English in Poland

1989 is considered to be one of, if not the most important years in the history of Poland. The end of communism and strong eastern influence has opened the country to a new era of modernization and connection with western Europe. That beginning of the new, contemporary Poland can be clearly seen in the language of its residents. While before the system change, Russian was the most commonly taught second language, now it is English with over 60% of Polish speakers claiming to know it at least on a communicative level (TNS Polska, 2015). To compare that, results from a survey from 2000 showed that only 43% of Polish speakers knew English and 78% of Polish speakers knew Russian, whereas in 2015 the latter dropped to 49% (TNS Polska, 2015).

This shift in language knowledge represents also the shift in culture, and how the languages are perceived. While many consider English to be the entryway to modernization or even as a mean of advancement in work field, there is a tension coming from those who believe that linguistically, English poses a threat to Polish language. Kasztalska (2014) explores the many views of English among Poles and describes how to many, English infiltrates Polish language and culture in the wrong manner. She further mentions how because of the major political events after the system change, such as Poland entering the European Union, many Poles face plurality issues. They believe in a linguistically and culturally unified nation, which consequently disregards bilingual and bidialectal Polish residents, even though their culture, while regional, is still Polish. The author also describes the attitudes towards native-like pronunciation among second language speakers and learners of English. Imitating the accent and mannerisms of native English speakers, specifically those from Great Britain or the United States, is highly praised and any divergence from the native-likeness should not take place as it is seen as "wrong". The reason behind this might be on one hand the prestige that English has as the language of the west in the eyes of native Polish speakers, and on the other hand, again the attitude that English and Polish should not interfere, so that Polish could still stay 'pure' and unified with no influence from other cultures. This shows how Poles tend to fall into extremes with their views on English, and its influence on local culture and language.

2.2. Aspiration

2.2.1. Phonological background

Phonetics and phonology cover the smallest compounds of a language, that is the sounds, as well as the rules they follow when interacting with each other, and the system they create to form a language. Voice onset time (VOT) is one of those characteristics and it describes the time between the release of a plosive and the onset of voicing, as shown in Figure 1.

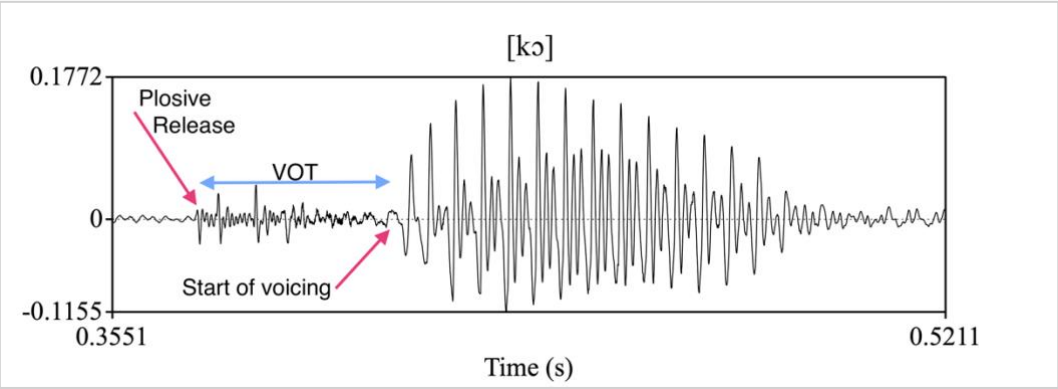

Figure 1. *Visualization of VOT measuring in a recording of [kɔ] by a native Polish speaker.*

Depending on the length of it, a plosive can be described as voiced, aspirated, or voiceless unaspirated. To be considered aspirated, a plosive should have a VOT greater than 30ms. English is a prime example of a language that has aspiration, with the mean VOT measure being 70ms (Lisker & Abramson, 1964), for example in the word [kʰæt] 'cat'. In comparison, Polish averages 32ms across its plosives (Keating et al. 1981), for instance in the word [kɔt] 'cat'. While English and Polish are binary in the sense of either present or absent aspiration, there exist languages like Mandarin Chinese that make use of them both (Cheng, 1966), and averages 103ms across its aspirated plosives (Rochet & Fei, 1991). This presence of aspirated versus non-aspirated minimal pair allows speakers of some languages have the ability of distinguishing between the contrasting sounds, as the change in VOT length in that case would also change the meaning of the word, for example in the words [tʰûtsɻ] 'bunny' and [tûtsɻ] 'abdomen' in Mandarin Chinese.

2.2.2. Phonetical background

Aspiration is a phonetic phenomenon that can be determined also by the physical elements attributed to different sounds that fall under phonetic universals. The further back the place of articulation of a sound is, the more likely it is to be aspirated due to longer track of air (Maddieson et al., 1996). Hence, even though Keating et al. (1981) showed that the mean VOT measure for Polish was above 30ms, no claim about Polish having aspiration was made. The measures were 22ms for /p/, 28ms for /t/, and 52ms for /k/. In comparison, English had 59ms, 67ms, and 84ms respectively (Lisker&Abramson, 1964). Based on that, there is an observable tendency for dorsal plosives to have longer VOTs regardless of the language, as expected from the phonetic universals. Vowel height is yet another aspect that can influence aspiration, namely higher vowels tend to make the preceding plosive more aspirated, whereas lower vowels tend to make the plosive sound more voiced (Maddieson et al., 1996).

Those universals show how languages can be categorized and provide a mean of comparison between each other that allows for studying both the independent qualities of languages, as well as their interactions and influences on one another.

2.3. Aspiration in Polish

Waniek-Klimczak (2011) researched the topic of aspiration as a possible sound change in Polish that was influenced by the knowledge and everyday use of English. The paper focused mainly on the effect of speech style, language experience, and the phonetic context in which the aspirated voiceless plosives would be used. Two groups were the subject of the research, both native Polish

speakers. One group with English as their L2, which was used as their lingua franca in everyday work life in Poland, and the second group that claimed to be monolingual with little to no experience in English. Their VOTs were measured both in isolation and in a more spontaneous dialogue. The need for two conditions is crucial due to attention-to-speech paradigm that suggests the level of attention to speech tends to be higher in more controlled environment, thus leading to more awareness and trying to produce the most "correct" sounds since the participants know that most likely their pronunciation is tested above everything else (Labov, 1972). The results found in Waniek-Klimczak's (2011) could not be concluded on individual level due to the small number of observations, mainly only 10 participants from each group. However, group-based observations showed significance. Overall, they suggest a strong influence of English experience and the speech style on lengthening the VOTs. Surprisingly the attention-to-speech paradigm (Labov, 1972) did not occur, and the results were opposite – the more controlled speech style, the longer the VOTs in both groups.

The current study takes a considerable amount of inspiration from Waniek-Klimczak (2011), as the latter was conducted thirteen years ago when English might not have been so widely used by everyday Polish speakers as compared to nowadays.

2.4. First language attrition

The effect of language knowledge on speakers' L1 is a broadly studied topic across the world and different languages, and research similar to Waniek-Klimczak's (2011) was also done on Brazilian Portuguese speakers. Schereschewsky et. al. (2018) focused on English bilinguals living in Brazil in their L1 dominant environment. The results showed some influence of English on participants' L1. The authors used the term attrition to describe this phenomenon and they did so because the change happening in the language was specific for non-monolinguals. The L2, here English, influences their L1 even when in their everyday lives Brazilian Portuguese is the dominating language, unlike how attrition usually happens, which is by using less L1 and more L2, for example because of moving to a differently speaking country. This poses a question that maybe what is possibly happening in Polish is in fact attrition and not sound change. Participants from Waniek-Klimczak's (2011) research were native L1 speakers, who just as participants from this study, lived in L1 dominant environment, but they differed in the usage of L2, since they used it in everyday life for work.

2.5. "Second-hand" attrition

But is it possible to experience attrition even without L2 knowledge? Baladzhaeva and Laufer (2018) demonstrated it was the case for Russian immigrants in Israel. Russian L1 speakers started emigrating to Israel in the 20th century and now make up the third largest native language group there. The migration was on such a scale, that Russian communities started to form and while most of the migrants have learned Hebrew, though some only orally, 26% of the first generation claimed to know barely any or nothing of the language (Central Bureau of Statistics (CBS) 2013). That is all due to multiple waves of migration, where the biggest one that happened between 1989 and 1993, brought around one million Russian speakers to Israel. Because of that, Russian communities expanded and became homogenous with almost everything being accessible in Russian, from doctors, lawyers and local grocery stores to national radio and TV channels. This is the main reason why some native Russian speakers living in Israel who were the first-generation migrants do not know Hebrew – they simply do not need it in their day to day lives.

In their previous exploratory study, Laufer and Baladzhaeva (2015) found that Russian speakers who claimed no Hebrew knowledge did not recognize the error when presented with a sentence in Russian but with Hebrew grammar. This gives an insight into how living in an environment without knowing the language spoken by the majority can still influence speakers' L1.

Baladzhaeva and Laufer's (2018) study shows significant results in language attrition and indicates that it can happen among monolinguals to the same extent or even more than among bilinguals. The authors called this phenomenon "second-hand" attrition. "Second-hand" because they believe that language attrition happened due to monolinguals being exposed to the attritted input from the bilinguals.

2.6. Present study

All the previous research is conclusive that there is indeed a considerate amount of influence of a second language on the first language, but it is not enough to determine what exactly is happening in Polish right now. English started to play a major role in modern Poland as Kasztalska (2015) described, especially since it is now the most commonly taught second language there with 96% of all students in primary and secondary schools being taught it (Głowny Urząd Statystyczny (GUS) 2023).

So, what is the case in Polish then? Would people who have been exposed to more English spoken media have longer VOTs in Polish, thus leading to producing aspirated plosives? It is possible that some Polish speakers would produce lengthened VOTs, but they would do so unknowingly, meaning they would not hear the difference if presented with a minimal pair. The reason behind it would be that Polish, unlike some other languages, such as Mandarin Chinese, does not have the contrasting pair of aspirated and unaspirated sounds, thus leaving room for ambiguity in perception by native speakers. The current research is a production and perception study that will focus on the length of VOTs produced by native Polish speakers who have been exposed to different amounts of English spoken media.

3. METHODOLOGY

3.1. Participants

For this research 21 participants of ages between 18-72 were recruited. 20 out of the 21 participants' recordings finished the isolated production part, 17 finished the spontaneous production part, and all 21 finished the perception part. The discrepancy in the number of participants occurred due to distortions that were present in the received sound files or due to participants not understanding the instructions. All experiments were treated independently, thus samples from all participants were analyzed, despite if they finished one, two, or all three experiments. They were native Polish speakers who were brought up in a monolingual household and currently live in their L1 dominant environment. It was crucial that they live in that environment so that bias from other languages can be excluded. They were recruited through convenience and snowball sampling.

The participants received a link that would redirect them to an online software designed specifically for the purpose of this research (Vet, 2024). The procedure was divided into three steps – the survey, the production experiment, and the perception experiment.

3.2. Survey

Before any questions appear, participants were shown the information brochure and asked to consent to the research through the informed consent form. During the first part, participants were asked to fill out a short survey that would assess their language background, personal details, such as age, gender, city they currently reside in, and their estimated exposure to English spoken media. Their English language background was in a form of self-report, based on the commonly used levels A1-C2, whereas the exposure to English spoken media was a Likert scale assessing the frequency of said exposure.

3.3. Isolated production

Before the experiment began, participants were instructed to situate themselves in a quiet room, with no background noise, including turning off fluorescent lamps and air conditioning. They were also advised to use headphones or a headset with a microphone, and the online software allowed participants to test their microphone level at the beginning of the experiment. Those instructions were given to the participants to ensure the best recording quality, as the experiment could have been done remotely.

The entire production part of the experiment was divided into two parts, based on the condition in which participants had to pronounce target words. During the first part, they were asked to pronounce words in more isolated environment, that is a simple carrier sentence.

3.3.1. Materials

The three plosives, /p/, /t/, and /k/ were tested in different word conditions, mainly before a high and a non-high vowel, in monosyllabic words, all of which sum up to 12 target words. Phonetic universals show that VOT measures tend to be longer in dorsal plosives rather than in coronal or labial plosives, as well as in shorter words, and when followed by a high vowel (Maddieson et al, 1996), hence the choice of those specific stimuli presented in Table 1 and Table 2. There were no filler words for this part due to the extensive number of examples.

/p/	/t/	/k/
puch [pux] 'fluff'	*tył* [tɨw] 'back'	*kuc* [kutsʲ] 'pony'
pin [pʲin] 'pin'	*tir* [tʲir] 'truck'	*kit* [kʲit] 'putty'

Table 1. *Isolated production experiment stimuli with a plosive followed by a high vowel.*

/p/	/t/	/k/
pech [pɛx] 'misfortune'	*tak* [tak] 'yes'	*kot* [kɔt] 'cat'
pan [pan] 'mister'	*tok* [tɔk] 'course'	*kat* [kat] 'executioner'

Table 2*. Isolated production experiment stimuli with a plosive followed by a non-high vowel.*

3.3.2. Procedure

As mentioned above, the first part of the production experiment focused on words in isolated simple sentences. All of them were the same carrier phrases, *ten X jest ładny* "this X is pretty", where X is the target word. Not all the target words are nouns, thus some sentences came out to be nonsensical, however they were still grammatical.

The sentences were displayed on the screen one by one, upon starting the experiment by the participant. Once the sentence was visible to the participant, the microphone would open and start recording their answer. When the participant pressed the spacebar to indicate they were done, the microphone would close, and their answer would be uploaded to the server.

3.4. Spontaneous production

In the second part of the production experiment the participants' role was to pronounce words in more lifelike and spontaneous conditions.

3.4.1. Materials

The same as in previous part, plosives /p/, /t/, and /k/ were tested. A total of 48 words was used for this segment of the experiment, with 12 words per each plosive that is tested and additional 12 fillers. All the target words begin with the plosive that is expected to be aspirated, though now there is a mix of both monosyllabic and disyllabic words. There was no overlap in any of the words from the first and the second part of this segment of the experiment (see Appendix A).

3.4.2. Procedure

After the participants were done with the previous task, this part's instructions appeared on the screen. This time the stimuli appeared on the screen all at once. The target words and the fillers were shuffled, and participants' role was to come up with and pronounce a short story using at least three out of the words they saw on the screen. The words could be used in multiple sentences or spread across one long sentence; the choice was up to the participant. The goal was to make the environment as true-to-life and spontaneous as possible while still controlling the use of the target words, thus there was also no time limit for the answer.

Similarly as in the previous task, once the words were visible on the screen the microphone would open and record their answer. It would keep recording until the participant had pressed spacebar to indicate they were done with the answer.

3.5. Perception

During the third part of the experiment, the perception test, the participants were presented with an ABX test that would determine if they were able to recognize the contrast between aspirated and non-aspirated plosives. Analogously as in the first part of the experiment, this was also be done in the software, right after they were done with the previous task.

3.5.1. Materials

Six short sentences were recorded by the researcher who is a native, female Polish speaker that does not produce aspirated plosives. Each one of the sentences was artificially modified to create longer VOTs in target words to create 6 pairs of sentences in total, with contrasting aspirated and non-aspirated sounds in the target words (Figure 2 and Figure 3). Similarly as in isolated production, this part did not contain any fillers due to the extensive number of examples.

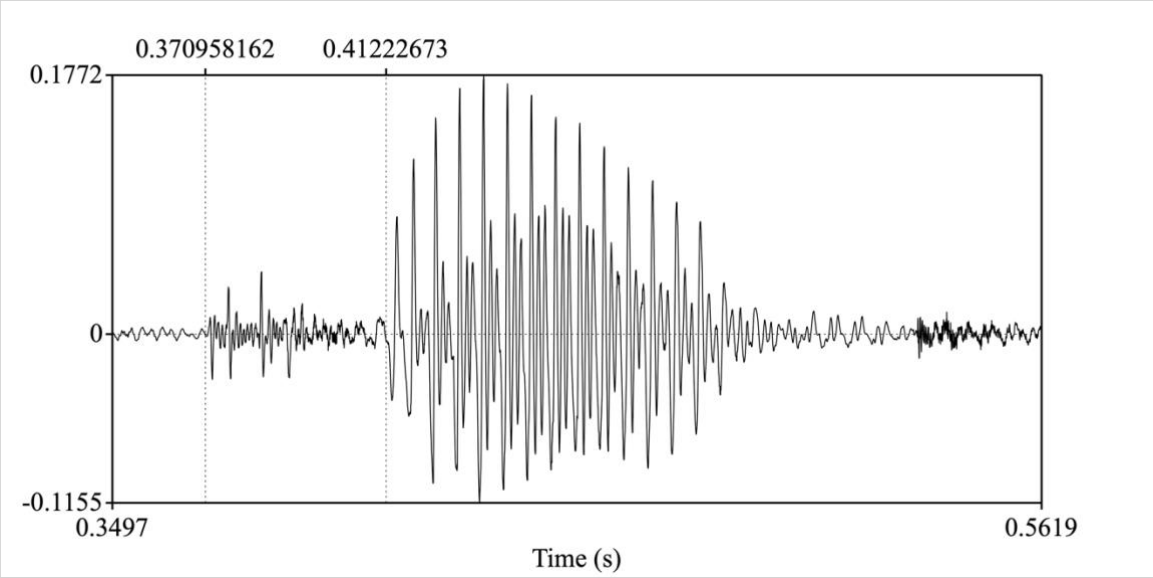

***Figure 2**. Original recording of word 'kot' in Polish (VOT≈40ms)*

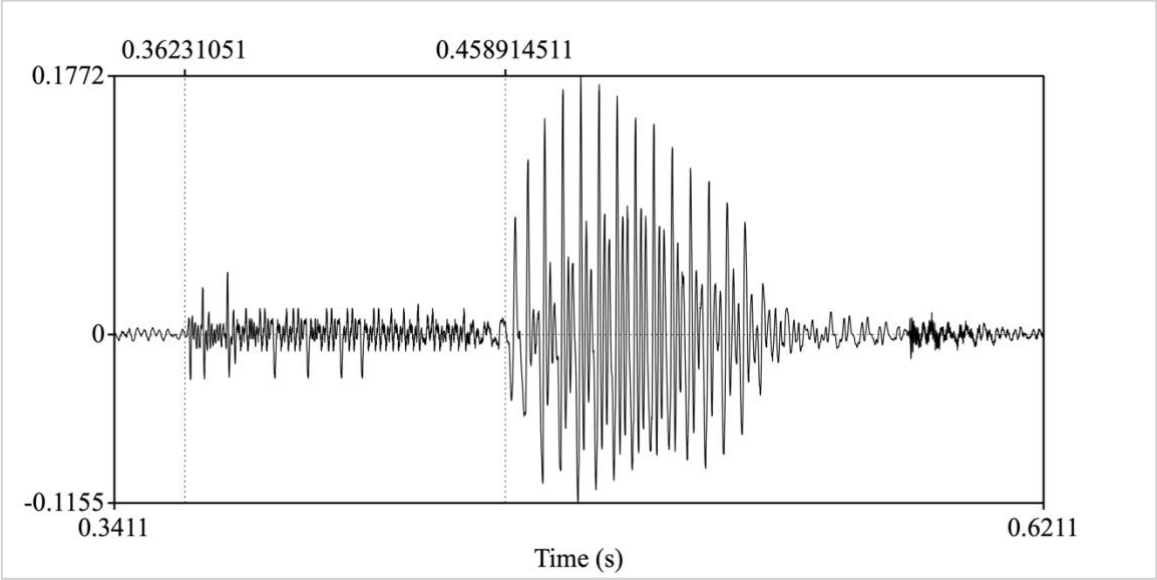

***Figure 3**. Artificially modified recording of word 'kot' in Polish (VOT≈90ms)*

3.5.2. Procedure

Participants heard three recordings in total for each round, with a total of 6 rounds. Each round consisted of an original recording with a non-aspirated plosive in the target word (A), a modified recording with an aspirated plosive (B), and a third recording chosen at random from the first two (X). Participants would hear the recordings only once and after each round they would be asked which sentence they heard last, whether it was A or B. All 21 participants finished this part fully.

4. RESULTS AND ANALYSIS

4.1. Isolated production results

All VOT measures were gathered by manually analyzing samples in Praat. A linear regression model was then applied to inspect the influence of variables on the length of VOT. The dependent variable was the length of VOT, whereas the independent were the exposure to English and the knowledge of English. The latter variable was included in results to compare the current study with Waniek-Klimczak's (2011) and was treated independently from exposure to English.

Table 3. shows results from the isolated production experiment. The intercept equaled to 22.69, indicating the base value of VOT. Exposure to English has a measure of 3.81 and p-value<0.05 which shows its significance and positive effect on lengthening the VOT. In this experiment, knowledge of English did not show significance with p-value=0.67.

Formula:

model_isolated <- lm(VOT ~ exposure_to_english + knowledge_of_english, data = data_isolated)

	Estimate	*95% CI*	*SE*	*t*	*p*
(Intercept)	22.69	[12.19, 33.19]	5.33	4.26	3×10^{-5}
Exposure to English	3.81	[0.26, 7.36]	1.80	2.11	**0.04**
Knowledge of English	0.56	[-2.07, 3.19]	1.33	0.42	0.67

Table 3. *Isolated production results.*

Table 4 presents mean VOT measures in ms across different exposure groups. The group exposed the most to English spoken media also had the highest overall VOT measures in the isolated speech production part with the mean equaling to 45.89ms. It was also the group with the most variability across samples with SD=25.21ms. Interestingly, all mean values fall above the 30ms threshold that defines the start of aspirated plosives. No participant responded "Never" in the survey; hence no results can be shown for that group.

Exposure level	*Mean VOT*	*95% CI*	*SD*
Never	NA	NA	NA
1-3 times a month	32.75	[27.55, 37.95]	17.9
Once a week	40.17	[24.93, 55.41]	23.99
A few times a week	34.85	[29.52, 40.19]	18.37
Everyday	45.89	[41.55, 50,23]	25.21

Table 4. *Mean VOT measures (ms) in different exposure groups in isolated production.*

Figure 4 presents how both exposure to English and knowledge of English apply to VOT measures in isolated speech production. A rising tendency in exposure to English can be observed which was also hinted with the p-value being lower than 0.05 for that variable. What can also be observed, is the distribution showing the possible interaction between the variables, where the group with the lowest knowledge of English claimed the least exposure to that language in media, and vice versa.

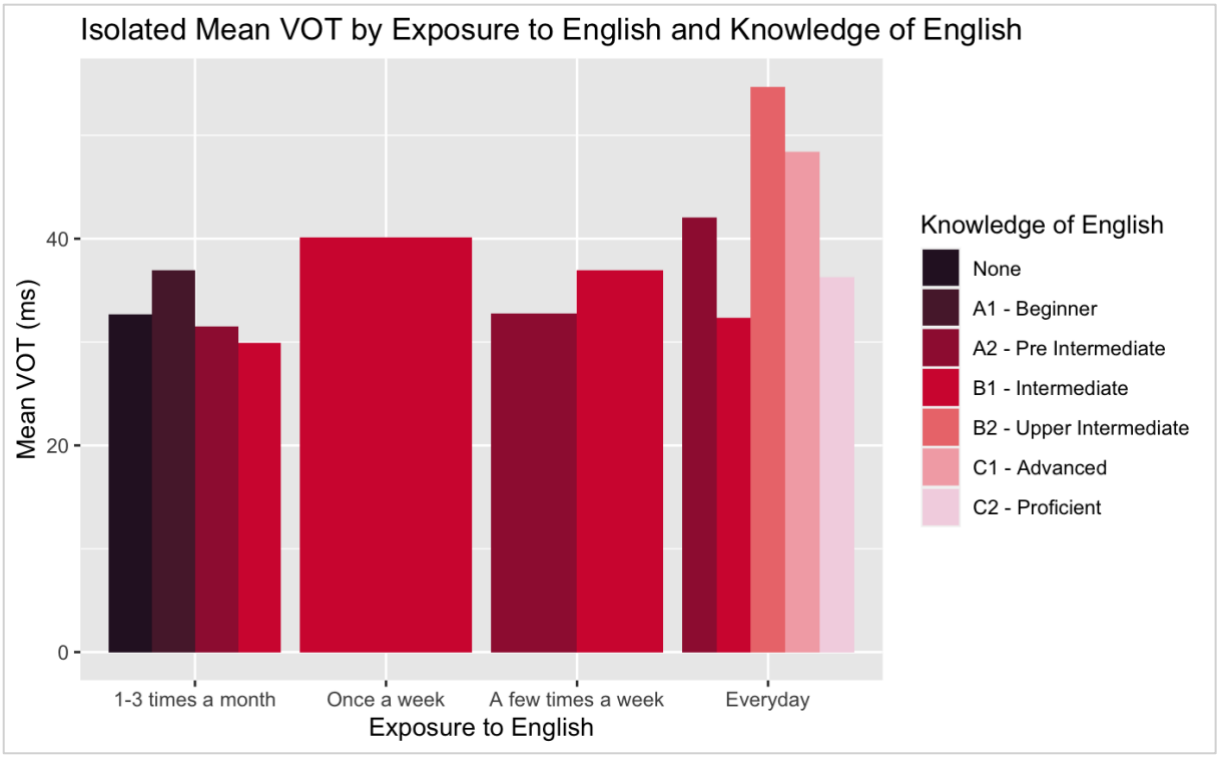

Figure 4. *Isolated production results including knowledge of English and exposure to English.*

4.2. Spontaneous production results

The same strategy as in the isolated production, on how measures were collected, was applied to the spontaneous production part. However, because Polish is a language with noun declination, and spontaneous speech production assumes the most lifelike conditions in which declination is inevitable, some standardization measures had to be employed. If the declined word still followed the convention of the target word, and the stress of the word fell on the initial syllable, in which the aspiration was to be observed, the word was added to the analysis. Otherwise, the word was excluded.

Table 5 shows results of the second part of the production experiment. Both exposure to English and knowledge of English were not significant factors in VOT lengthening in spontaneous speech conditions with p-value being greater than 0.05 for each variable.

Formula:

model_spontaneous <- lm(VOT ~ exposure_to_english + knowledge_of_english, data = data_spontaneous)

	Estimate	*95% CI*	*SE*	*t*	*p*
(Intercept)	22.87	[4.29, 41.46]	9.39	2.44	0.02
Exposure to English	5.00	[-1.25, 11. 24]	3.16	1.58	0.12
Knowledge of English	-1.13	[-5.54, 3.28]	2.23	-0.51	0.61

Table 5. *Spontaneous production results.*

Mean VOT measures for each exposure group in spontaneous speech production are presented in Table 6. Here, similarly as in isolated speech production, the group who claimed the most exposure to English spoken media showed the longest VOTs overall (mean=42.42ms). This is again the group with the most variability in their measures (SD=25.23ms). The group that had the second highest mean was surprisingly the one who claimed the least exposure to English. "Never" group was excluded again, due to lack of respondents in this category.

Exposure level	*Mean VOT (ms)*	*95% CI*	*SD*
Never	NA	NA	NA
1-3 times a month	35.64	[24.67, 46.62]	19.01
1 time a week	28.78	[17.19, 40.36]	15.07
A few times a week	25.50	[16.45, 34.55]	15.67
Everyday	42.42	[37.14, 47.71]	25.23

Table 6. *Mean VOT measures (in ms) in different exposure groups in spontaneous production.*

Table 7 presents the mean VOT measures across different places of articulation. The results are shown in this manner due to the vast amount of variance between participants and the number of stimuli used for this part. While labial and coronal POA showed no aspiration, measuring 27.18ms and 29.69ms respectively, dorsal POA showed significant aspiration with VOT length reaching 61.20ms on average. What can be observed here, is the rising VOT length tendency where the further back the place of articulation in spontaneous speech, the longer VOTs were produced. This observation is in line with the assumptions made based on the phonetic universals, meaning dorsal plosives will have longer VOTs due to longer track of air.

POA	*Mean VOT (ms)*	*95% CI*	*SD*
Labial	27.18	[23.00, 31.36]	12.90
Coronal	29.69	[25.48, 33.90]	14.50
Dorsal	61.20	[53.02, 69.38]	25.59

Table 7*. Mean VOT measures (in ms) across places of articulation in spontaneous production.*

Figure 5 visualizes the parabola shape of the results distribution, where the groups with the most and the least exposure to English produced the longest VOTs on average. Due to the mostly the same pool of participants, the connection between the knowledge and exposure to English can also be observed on this figure, similarly as in Figure 4. No participant who claimed no knowledge of English took part in this experiment, thus category "None" in the knowledge of English is excluded from the visualization.

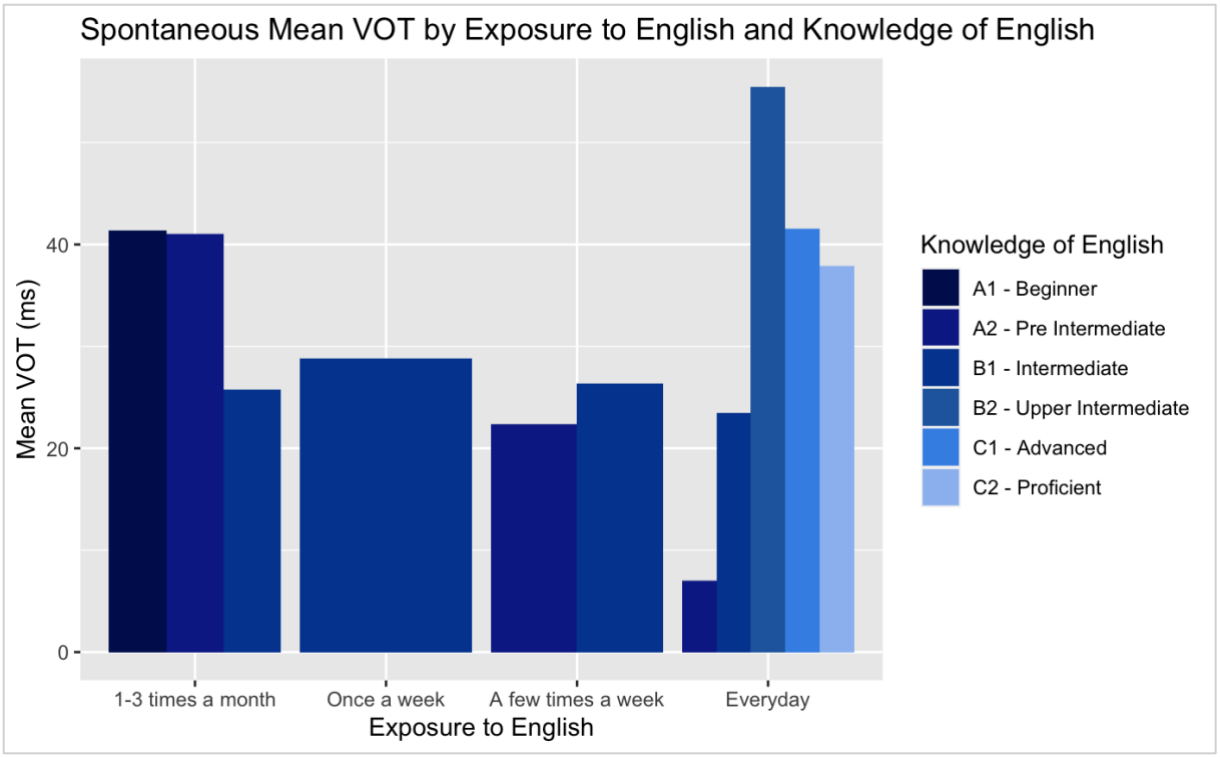

Figure 5. *Spontaneous production results including knowledge of English and exposure to English.*

4.3. Total production results

All production data was also analyzed together and Table 8 and Table 9 present the results of it. In total, exposure to English showed significance, as it did in isolated speech production (p-value<0.01).

Formula:

lm(formula = VOT ~ exposure_to_english + knowledge_of_english, data = data)

	Estimate	*95% CI*	*SE*	*t*	*p*
(Intercept)	23.33	[14.26, 32.41]	4.62	5.06	6.84×10^{-7}
Exposure to English	4.37	[1.31, 7.43]	1.56	2.81	**0.005**
Knowledge of English	-0.35	[-2.49, 1.80]	1.09	-0.32	0.75

Table 8. *Total production results.*

Table 9 presents the mean VOT measures from both production experiments for each exposure group. The group that claimed daily exposure to English spoken media produced the longest VOTs (mean=44.49). Similarly to the isolated production, this group also presents the most variability with SD=25.22. The other three exposure groups have roughly similar mean VOTs ranging between 32.74 and 35.29 on average.

Exposure level	*Mean VOT (ms)*	*95% CI*	*SD*
Never	NA	NA	NA
1-3 times a month	33.40	[28.82, 37.98]	18.04
1 time a week	35.29	[25.73, 44.84]	20.99
A few times a week	32.74	[28.14, 37.34]	18.11
Everyday	44.49	[41.15, 47.82]	25.22

Table 9. *Mean VOT measures (in ms) among different exposure groups in total.*

Figure 6 visualizes the combined results from both production experiments. It shows the overall distribution is more like the isolated production one rather than spontaneous in the way it is shaped. Once again, there is a clear distribution of color symbolizing the connection between how much someone is exposed to English spoken media based on their knowledge of said language.

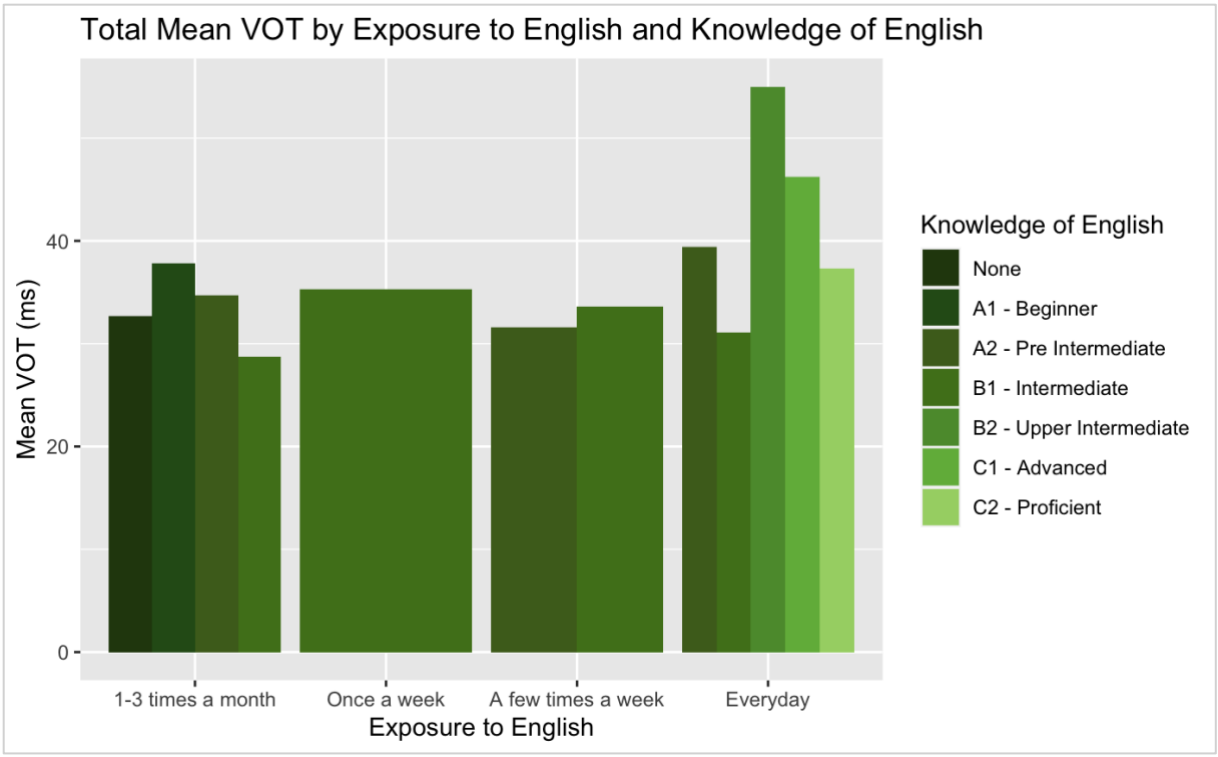

Figure 6. *Total production results including knowledge of English and exposure to English.*

4.4. Production experiments - secondary factors

During data collection, other factors were gathered as well, and some showed significance in analysis. A linear regression model with all possible factors was employed and points worth mentioning are age, vowel height, and place of articulation.

Formula:

model <- lm(VOT ~ POA + production_context + VH + exposure_to_english + knowledge_of_english + gender + age + place_of_residence, data = data)

As expected, dorsal place of articulation had the largest effect on the length of VOT. Labial plosives also showed significance overall, with both sounds having p-value<0.05. Coronal place of articulation did not show significant results in regard to VOT lengthening.

What came as a surprise was the significant effect of non-high vowels rather than high vowels. Based on phonetic universals, plosives followed by high vowels are prone to being more aspirated, but that was not the case in the current study. Even in comparison with all other variables, it was non-high vowels that still reached significance level of p<0.05.

The last variable that showed significance is the age of participants. There was a significant cut-off for the ages that were significant, namely 40 years old. Age of nearly all participants below that threshold showed significance effect on VOT lengthening ($p<0.05$).

4.5. Production analysis

Before going in depth into the analysis, it is important to repeat the main research question, and that is "Is it possible that more exposure to English spoken media can lead to producing longer VOTs in Polish, resulting in aspirated plosives?"

When analyzing the results presented above, a firm conclusion can be made, namely the exposure of native Polish speakers to English spoken media can be a significant factor in VOT lengthening in Polish in isolated speech production, as well as when considering the production experiment in total. The observed aspiration of Polish plosives in isolated speech and not in spontaneous speech is contradictory to the attention-to-speech paradigm (Labov 1972). This is an interesting occurrence, since the results from Waniek-Klimczak (2011) showed the same paradox, where people with more English knowledge also produced longer VOTs in more isolated speech conditions. The repetition of said lack of attention-to-speech paradigm can shed a light on the possible sound change happening in Polish. More specifically, the absence of the paradigm, or moreover its opposite, could mean that now the longer VOTs, that were produced in isolated speech are the quality of standard Polish.

Moreover, the two studies on aspiration in Polish show how both passive and active contact with English can influence the length of VOT when speaking Polish. Those results show that even with some Poles, who have negative attitudes towards English infiltrating their native language, some changes are inevitable, regardless of the type of contact with the language. While something like starting to use borrowings is a more obvious type of language change to an untrained eye, a phonetic phenomenon such as aspiration is more subtle. It is harder to point out and correct, and consequently making its way into a language like Polish much easier.

What is also an essential factor, is the correlation between age of participants and VOT lengthening. As more and more young people learn English, alongside the rise of English media becoming more easily accessible, it is inescapable that people will be more exposed to the language. While the results did show a correlation between language knowledge and exposure, it was the latter that yielded significant results.

Another surprising finding was the effect of vowel height on aspiration. The expectations based on phonetic universals, assumed that plosives followed by a high vowel tend to be aspirated, while plosives followed by a non-high vowel are more likely to be voiced. Yet, this study showed that it was the non-high vowel that led to lengthening of the VOTs. This means that the results were not only significant but moreover, opposite to what was expected. That finding could mean that Polish does not adhere to the universals and is therefore unique in the production of plosives.

4.6. Perception / ABX test

Table 9 presents the overall accuracy scores of the perception experiment in a form of an ABX test. The word that was matched correctly the most is *kot* with accuracy reaching 62%. The word that was matched the least correctly was *ten* where accuracy rate was only 38%. When looking at the place of articulation, it was dorsal plosives that had the highest accuracy rate of 57% overall. While particular scores vary, the general accuracy rate is 49%.

Accuracy	*petów*	*Paweł*	*tak*	*ten*	*kot*	*kawa*
per word	43%	48%	52%	38%	62%	52%
per POA	45%		45%		57%	
Total	**49%**					

Table 10. *Accuracy results of ABX experiment.*

This part of the research question focused on the conscious ability to differentiate between aspirated and non-aspirated plosives, based on the lack of said contrast in Polish. While the production experiments yielded generally significant results, perception experiment did not show such significance. Based on the overall accuracy score, namely 49%, the only thing that can be concluded is that the accuracy is a result of chance. The results per particular words give some room for speculation, as to what could have caused some scores to be more or less accurate than others, though it is not enough for anything certain to be determined. Because of the null results, the comparative analysis of both production and perception experiments cannot be done.

5. DISCUSSION AND CONCLUSION

The aim of this study was to explore the emerging nature of aspiration in Polish. While previous studies focused on the effect of knowledge of English on the presence of aspiration among native Polish speakers, the current research tried to fill in the gap that was the correlation between the

exposure to English spoken media and said phenomenon. This was based on the rise of English as the most common second language in Poland, following the historical events of the last few decades, as well as the feelings of Poles about the native-like pronunciation in English, and at the same time, the negative attitude towards the interference between the languages.

The results of the current study show that English has a significant effect on language change in Polish. When combined with the research by Waniek-Klimczak (2011), a firm conclusion can be drawn, that not only the active contact with the language, in a form of its usage on a daily basis, but also the passive exposure to it, in media in this case, can lead to changes in Polish speakers' L1.

The significance of some results opened a new door to speculation and possible further research on the specific language characteristics of Polish, such as the lack of attention-to-speech paradigm (Labov, 1972) or the lengthening of VOT before non-high vowels that is conflict with the phonetic universals. Although the production experiments in this study were not short by any means, follow-up research would highly benefit from more samples over a larger participant pool. This also applies to the perception experiment which in the current study was not as extensive as it could be, if the time restriction was not such a vast requirement, or the study was focused primarily on that particular type of experiment. Another improvement that would benefit the outcome of further research on this topic, is the ability to conduct the experiments in person. This would eliminate the errors regarding recording quality, that sometimes made it impossible for samples to be analyzed, as well as the problems with understanding the instructions, specifically for the spontaneous production experiment, that was an innovative mean of gathering more lifelike and raw data but posed difficulties for some participants.

This study took inspiration and main concepts ideas from previous research and applied it all to create a new understanding of the current situation of native Polish speakers in regard to English influencing the language change. It showed, how Polish has adapted over the past thirteen years since the study by Waniek-Klimczak (2011), as well as how much standard Polish has changed over decades, when looking back at the standard VOT measures published in the 1980s (Keating et al., 1981). This is yet another example of regardless how much people try to preserve the language they know, how Kasztalska (2015) described in her work on the mixed feelings of Poles about English being more and more widespread across media and culture, it is unavoidable that languages come in contact and change.

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APPENDIX A – Survey

Original survey translated into English:

1. Age: ……
2. Gender:
   - Female
   - Male
   - Other
3. Place of residence (Province and city): ……
4. How do you rate your English knowledge:
   - None
   - Level A1 (beginner)
   - Level A2 (beginner)
   - Level B1 (intermediate)
   - Level B2 (intermediate)
   - Level C1 (advanced)
   - Level C2 (advanced)
5. How often do you come into contact with media where you hear English clearly? (e.g. English language films with subtitles instead of dubbing/voice-over, social media e.g. Tiktok/Instagram reels, etc.)
   - Never
   - 1-3 times a month
   - Once a week
   - A few times a week
   - Everyday

APPENDIX B – Spontaneous production stimuli

TARGET WORDS:

papier	po	pole
pegaz	patrol	powódź
polo	porost	pas
poczta	paproć	pismo

tor	teren	korek
tak	torba	kiwi
to	tukan	kula
ten	tandem	kasa
tamten	kot	kaktus
tego	kilo	korek
tango	kolej	kupić
taras	kawał	kara

FILLERS:

woda	mesa	maska
miasto	zapach	zawód
łódź	blok	dom
wata	wazon	bez

APPENDIX C – Perception stimuli

Target word, that was artificially modified, in each pair is underlined:

Pan Paweł biega.

Nie rzucaj petów na ziemię.

Gdzie ty tak pędzisz?

To właśnie ten moment tworzy historię.

Maria codziennie parzy kawę do śniadania.

Każdy kot lubi spać.

APPENDIX D - R script

```
---
title: "Thesis data 1"
author: "Liwia Sokół"
date: "2024-05-30"
output:
  html_document: default
  word_document: default
  pdf_document: default
---

```{r setup, include=FALSE}
options(repos = c(CRAN = "https://cran.rstudio.com/"))
knitr::opts_chunk$set(echo = TRUE)
```
```

```
utils::install.packages("broom")
```

```{r}
library(readr)
install.packages("broom")
results_final <- read.csv("results_final.csv", sep = ";" )
```

WHOLE EXPERIMENT

```{r}
# Load necessary libraries
library(psych)
# Load your data
data <- read.csv("results_final.csv", sep = ";")

# Ensure your categorical variables are treated as factors

# this is for the whole thing
data$POA <- factor(data$POA)
data$production_context <- factor(data$production_context)
data$VH <- factor(data$VH)
data$exposure_to_english <-
as.numeric(data$exposure_to_english, levels = 1:5, ordered =
TRUE) #not factor but numerical
data$knowledge_of_english <-
as.numeric(data$knowledge_of_english, levels = 1:7, ordered =
TRUE) #not factor but numerical
data$gender <- factor(data$gender)
data$age <- factor(data$age)
data$place_of_residence <- factor(data$place_of_residence)  #
Ensure this is treated as a factor

# Fit the linear model

model <- lm(VOT ~ POA + production_context + VH +
exposure_to_english + knowledge_of_english + gender + age +
place_of_residence, data = data)

# Summary of the model
summary(model)
confint(model)
```

isolated VOT ~ exposure, knowledge
```{r}
# Load necessary libraries
library(psych)
```

```
# Load your data
data <- read.csv("results_final.csv", sep = ";")

# Ensure your categorical variables are treated as factors

data$exposure_to_english <-
as.numeric(data$exposure_to_english, levels = 1:5, ordered =
TRUE)
data$knowledge_of_english <-
as.numeric(data$knowledge_of_english, levels = 1:7, ordered =
TRUE)

# Filter data to include only the 'Isolated' production
context
data_isolated <- subset(data, production_context ==
"isolated")

# Fit the linear model
model_isolated <- lm(VOT ~ exposure_to_english +
knowledge_of_english, data = data_isolated)

# Summary of the model
summary(model_isolated)
confint(model_isolated)
```
spontaneous VOT ~ exposure, knowledge
```{r}
# Load necessary libraries
library(psych)
# Load your data
data <- read.csv("results_final.csv", sep = ";")

# Ensure your categorical variables are treated as factors

data$exposure_to_english <-
as.numeric(data$exposure_to_english, levels = 1:5, ordered =
TRUE)
data$knowledge_of_english <-
as.numeric(data$knowledge_of_english, levels = 1:7, ordered =
TRUE)

# Filter data to include only the 'Isolated' production
context
data_spontaneous <- subset(data, production_context ==
"spontaneous")

# Fit the linear model
model_spontaneous <- lm(VOT ~ exposure_to_english +
knowledge_of_english, data = data_spontaneous)

# Summary of the model
```

```
summary(model_spontaneous)
confint(model_spontaneous)
```
whole thing VOT ~ exposure, knowledge
```{r}
# Load necessary libraries
library(psych)
# Load your data
data <- read.csv("results_final.csv", sep = ";")

# Ensure your categorical variables are treated as factors

data$exposure_to_english <-
as.numeric(data$exposure_to_english, levels = 1:5, ordered =
TRUE)
data$knowledge_of_english <-
as.numeric(data$knowledge_of_english, levels = 1:7, ordered =
TRUE)


# Fit the linear model
model_full <- lm(VOT ~ exposure_to_english +
knowledge_of_english, data = data)

# Summary of the model
summary(model_full)
confint(model_full)
```
confidence interval isolated
```{r}
library(dplyr)
library(broom)
# Summarize the data
isolated_summary <- data_isolated %>%
  group_by(exposure_to_english) %>%
  summarize(
    mean_vot = mean(VOT, na.rm = TRUE),
    sd_vot = sd(VOT, na.rm = TRUE),
    n = n()
  )

# Calculate the standard error and confidence intervals
isolated_summary <- isolated_summary %>%
  mutate(
    se = sd_vot / sqrt(n),
    ci_lower = mean_vot - qt(0.975, df = n-1) * se,
    ci_upper = mean_vot + qt(0.975, df = n-1) * se
  )

# Print the summarized data with confidence intervals
print(isolated_summary)
```

```

# confidence interval spontaneous
```{r}
library(dplyr)
library(broom)
# Summarize the data
spontaneous_summary <- data_spontaneous %>%
  group_by(exposure_to_english) %>%
  summarize(
    mean_vot = mean(VOT, na.rm = TRUE),
    sd_vot = sd(VOT, na.rm = TRUE),
    n = n()
  )

# Calculate the standard error and confidence intervals
spontaneous_summary <- spontaneous_summary %>%
  mutate(
    se = sd_vot / sqrt(n),
    ci_lower = mean_vot - qt(0.975, df = n-1) * se,
    ci_upper = mean_vot + qt(0.975, df = n-1) * se
  )

# Print the summarized data with confidence intervals
print(spontaneous_summary)
```

confidence interval full
```{r}
library(dplyr)
library(broom)
# Summarize the data
full_summary <- data %>%
  group_by(exposure_to_english) %>%
  summarize(
    mean_vot = mean(VOT, na.rm = TRUE),
    sd_vot = sd(VOT, na.rm = TRUE),
    n = n()
  )

# Calculate the standard error and confidence intervals
full_summary <- full_summary %>%
  mutate(
    se = sd_vot / sqrt(n),
    ci_lower = mean_vot - qt(0.975, df = n-1) * se,
    ci_upper = mean_vot + qt(0.975, df = n-1) * se
  )

# Print the summarized data with confidence intervals
print(full_summary)
```
```

context

```{r}
describeBy(data, list(data$production_context))
```

exposure isolated

```{r}
describeBy(data_isolated,
list(data_isolated$exposure_to_english))
```

exposure spontaneous

```{r}
describeBy(data_spontaneous,
list(data_spontaneous$exposure_to_english))
```

exposure full

```{r}
describeBy(data, list(data$exposure_to_english))
```
word isolated
```{r}
describeBy(data_isolated, list(data_isolated$word))
```
word spontaneous POA
```{r}
describeBy(data_spontaneous, list(data_spontaneous$POA))
```

knowledge isolated

```{r}
describeBy(data_isolated,
list(data_isolated$knowledge_of_english))
```

knowledge spontaneous

```{r}
describeBy(data_spontaneous,
list(data_spontaneous$knowledge_of_english))
```

gender

```{r}
describeBy(data, list(data$gender))
```

age

```{r}
describeBy(data, list(data$age))
```

place of residence

```{r}
describeBy(data, list(data$place_of_residence))
```

graph mean isolated
```{r}
# Calculate mean VOT for each combination of
exposure_to_english and knowledge_of_english
mean_vot <- aggregate(VOT ~ exposure_to_english +
knowledge_of_english, data = data_isolated, FUN = mean)

# Create a bar plot
ggplot(mean_vot, aes(x = exposure_to_english, y = VOT, fill =
as.factor(knowledge_of_english))) +
  geom_bar(stat = "identity", position = "dodge") +

  #changing the names of the labels
    scale_fill_manual(name = "Knowledge of English",
                      labels = c("None", "A1 - Beginner", "A2
- Pre Intermediate", "B1 - Intermediate", "B2 - Upper
Intermediate",
                                 "C1 - Advanced", "C2 -
Proficient"),
                      values = c("#2c152b", "#582137",
"#9f1d3f", "#d4213d", "#ec797b", "#f3acb3", "#f3d6e3")) +
    scale_x_discrete(name = "Exposure to English",
                     labels = c("1-3 times a month", "Once a
week", "A few times a week", "Everyday")) +
  labs(title = "Isolated Mean VOT by Exposure to English and
Knowledge of English",
       x = "Exposure to English",
       y = "Mean VOT (ms)")
  theme_minimal() +
  theme(
    panel.background = element_blank(),  # Remove panel
background
```

```
    plot.background = element_blank(),   # Remove plot
background
    panel.grid.major = element_blank(),  # Remove major grid
lines
    panel.grid.minor = element_blank(),  # Remove minor grid
lines
    axis.line = element_line(color = "black")  # Keep axis
lines
  )
```
graph mean spontaneous
```{r}

mean_vot <- aggregate(VOT ~ exposure_to_english +
knowledge_of_english, data = data_spontaneous, FUN = mean)

# Create a bar plot
ggplot(mean_vot, aes(x = exposure_to_english, y = VOT, fill =
as.factor(knowledge_of_english))) +
  geom_bar(stat = "identity", position = "dodge") +

  #changing the names of the labels
    scale_fill_manual(name = "Knowledge of English",
                      labels = c("A1 - Beginner", "A2 - Pre
Intermediate", "B1 - Intermediate", "B2 - Upper Intermediate",
                                 "C1 - Advanced", "C2 -
Proficient"),
                       values = c("#00165c", "#0d2994",
"#01469f", "#2368ac", "#4292e7", "#9cbef0")) +
    scale_x_discrete(name = "Exposure to English",
                     labels = c("1-3 times a month", "Once a
week", "A few times a week", "Everyday")) +
  labs(title = "Spontaneous Mean VOT by Exposure to English
and Knowledge of English",
       x = "Exposure to English",
       y = "Mean VOT (ms)")
  theme_minimal()
```

graph mean all together
```{r}
# Calculate mean VOT for each combination of
exposure_to_english and knowledge_of_english
mean_vot <- aggregate(VOT ~ exposure_to_english +
knowledge_of_english, data = data, FUN = mean)

# Create a bar plot
ggplot(mean_vot, aes(x = exposure_to_english, y = VOT, fill =
as.factor(knowledge_of_english))) +
  geom_bar(stat = "identity", position = "dodge") +
```

```
  #changing the names of the labels
    scale_fill_manual(name = "Knowledge of English",
                      labels = c("None", "A1 - Beginner", "A2
- Pre Intermediate", "B1 - Intermediate", "B2 - Upper
Intermediate",
                                 "C1 - Advanced", "C2 -
Proficient"),
                       values = c("#28440e", "#2c591b",
"#4d6b22", "#507f1f", "#5c9839", "#72b649", "#a5d374")) +
    scale_x_discrete(name = "Exposure to English",
                     labels = c("1-3 times a month", "Once a
week", "A few times a week", "Everyday")) +
  labs(title = "Total Mean VOT by Exposure to English and
Knowledge of English",
       x = "Exposure to English",
       y = "Mean VOT (ms)")
  theme_minimal()
```

confidence interval POA spontaneous
```{r}
library(dplyr)
library(broom)
# Summarize the data
full_summary <- data_spontaneous %>%
  group_by(POA) %>%
  summarize(
    mean_vot = mean(VOT, na.rm = TRUE),
    sd_vot = sd(VOT, na.rm = TRUE),
    n = n()
  )

# Calculate the standard error and confidence intervals
full_summary <- full_summary %>%
  mutate(
    se = sd_vot / sqrt(n),
    ci_lower = mean_vot - qt(0.975, df = n-1) * se,
    ci_upper = mean_vot + qt(0.975, df = n-1) * se
  )

# Print the summarized data with confidence intervals
print(full_summary)
```