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EXPERIMENTAL ECONOMICS MEETS LANGUAGE CHOICE

by

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Experimental Economics Meets Language Choice*

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Abstract

Roughly one half of World's languages are in danger of extinction. The endangered languages, spoken by minorities, typically compete with powerful languages such as English or Spanish. Consequently, the speakers of minority languages have to consider that not everybody can speak their language, converting the language choice into strategic, coordination-like situation. We show experimentally that the displacement of minority languages may be partially explained by the imperfect information about the linguistic type of the partner, leading to frequent failure to coordinate on the minority language even between two speakers who can and prefer to use it. The extent of miscoordination correlates with how minoritarian a language is and with the real-life linguistic condition of subjects: the more endangered a language the harder it is to coordinate on its use, and people on whom the language survival relies the most acquire behavioral strategies that lower its use. Our game-theoretical treatment of the issue provides a new perspective for linguistic policies.

Keywords: bilingualism, coordination, experiments, game theory, imperfect information, language choice, minority languages.

JEL Classification: C72, C91, D80.

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1 Introduction

The economic literature increasingly recognizes the socio-economic benefits of linguistic diversity (Ginsburgh and Weber, 2011; Grin et al., 2010) and public authorities all around the Globe spend large resources to promote the knowledge of minority languages. These languages often interact with other languages in a situation of *language contact* (Crystal, 1987; Winford, 2003).[1] In most cases, minority languages "compete" with powerful languages such as English or Spanish that receive large support emanated from sovereign states and the network of public and private institutions. In contrast, minority languages typically have relatively little political weight. Since minorities commonly speak the majoritarian languages, the survival of most real-life endangered languages relies on language choices of bilingual individuals and we have to distinguish the *knowledge* of minority languages (i.e. the proportion of speakers of the language) from their *use* (i.e. the proportion of people using the language in their conversations). As a result of the language contact, the *use* of the minority language is often significantly reduced (see e.g. Altuna and Basurto, 2013) and such languages and their related cultures are at high risk of being displaced by majority languages (Fishman, 1991, 2001) even if the knowledge indices suggest otherwise.

The purpose of this study is to explore experimentally the extent and the determinants of failure to coordinate on the (language) option preferred by the bilingual members of a society in a game formally equivalent to a conversation.[2] We analyze a society with two official languages, one majoritarian and one minoritarian denoted respectively A and B. The population is divided into two linguistic groups: a share $1 - \alpha$ of monolingual speakers only know A whereas a share α of bilingual speakers speak both A and B. As the first treatment variation, we manipulate systematically the share of "bilingual" speakers in the population, α, to see how the coordination on the minority language B is affected by the linguistic composition of the population.

Furthermore, to exploit that our experiment was conducted in a society where two linguistically unrelated languages coexist, the minoritarian Basque and the majoritarian Spanish, we conducted sessions in both Basque and Spanish and analyze the effects of subjects' linguistic conditions (monolingual and two types of bilinguals, those with Spanish or Basque as the

[1] In sociolinguistics, two or more languages are in language contact when they are used in the same social group. See Crystal (1987) or Winford (2003) for exhaustive treatments of these issues.

[2] We follow the seminal papers of van Huyck et al. (1990, 1991) and term coordination failure any outcome different from the coordination on the efficient situation (i.e. even if coordination occurs but on an inefficient outcome).

mother tongue) on their behavior.[3] Hence, our study can be viewed as an artefactual experiment, i.e. conventional experiment with a nonstandard subject pool (Harrison and List, 2004). An extensive experimental literature has shown that people apply in the lab the heuristics they developed in the field (see e.g Cooper et al. (1999), Fehr and List (2004), Palacios-Huerta and Volij (2008, 2009) among many others). We find crucial to understand the language choices of bilingual people, on which the survival of endangered languages relies the most in real life.[4]

Following the approach pioneered by Hong and Plott (1982), Grether and Plott (1984), and later exploited by others (e.g. Fehr and List (2004) or Palacios-Huerta and Volij (2008, 2009)), we designed the experiment as neutral as possible. This is a key aspect of our analysis because in societies where languages are in contact and typically in conflict, bringing languages to the lab might condition participants' behavior to a great extent. Hence, our subjects play a game with a structure similar to a conversation, in which bilinguals may meet monolinguals. However, no reference to a conversation was made in the instructions and languages were referred to as actions A or B. The only parameter found in the field and used in the experiment are the plausible proportions of bilinguals in the population, α. This design feature allows us to separate the coordination problems from emotional issues attached to language choice in real life.

Our analysis applies to language contact in modern, economically advanced societies with democratic regimes characterized by a high mobility of the population, in which the minority languages are not associated with low status, and in which the share of bilingual speakers can be estimated. High mobility (both social and geographical) leads to frequent anonymous interactions, in which bilingual speakers choose their language in conversations with others under *imperfect information* about the linguistic type of the speech partner. In these societies, the social preference in favour of the preservation and promotion of the minority language B

[3] In the Basque country, the mother tongue of a bilingual individual also serves as an index for the age of the second-language acquisition. Spanish-speaking families do not normally transmit Basque to their children. If their children speak Basque, they learnt it at school. In contrast, virtually all Basque-speaking individuals are bilingual and children in Basque-speaking families learn Spanish from early childhood in their everyday interactions. Hence, following e.g. Mechelli *et al.* (2004), we label the bilingual subjects stating Basque (Spanish) as their mother tongue as *early* (*late*) *bilinguals* below.

[4] Mechelli et al. (2004) report that the structural organization of human brain is affected by the bilingualism of individuals and the age at acquisition of the second language and Chen (2013) documents that the grammatical structure of languages influences human economic behavior. Hence, there may be behavioral differences across the three linguistic types in our experiment.

emerges through voting or any other preference-aggregation mechanism pointing to its high enough prestige. Moreover, the estimates of the probability of the partner being bilingual (α) are publicly available.[5] Finally, we shall assume that A and B are linguistically distant, such that successful communication is only possible in the same language.[6] Examples of such societies include the Basque Country (Basque vs. French or Spanish), French Brittany (Breton vs. French), Ireland (Irish vs. English), Scotland (Scottish Gaelic and English) and Wales (Welsh and English).[7]

We observe that the failure to coordinate in the preferred action B is commonplace. The extent of coordination failure decreases with the share α. We also uncover that, somehow surprisingly, bilingual individuals who state the minoritarian Basque as their mother tongue (the early bilingual individuals) coordinate more often on the majority option A in the lab; in contrast, both the late bilingual and the monolingual participants' choices exhibit higher rates of coordination on B in our context-free setup. These results convey two bad news for the survival of languages: (i) the more endangered a language the harder it is to coordinate on its use and (ii) people on whom the language survival relies the most acquire behavioral strategies that lower their use even further. In addition, we show that a combination of bounded rationality and some recent behavioral approaches can explain why we observe more (less) coordination than predicted for low (high) α and why the behavior of early bilinguals may differ.

Language competition was studied first by Abrams and Strogatz (2003). Their work gave rise to a fruitful research area on the issues related with language competition dynamics (see Patriarca *et al.* (2012) for a review). Recently, there appears to be an increasing interest among economists about language-related issues (see the surveys by Ginsburgh and Weber (2011) and Grin *et al.* (2010)). Rubinstein (1996) and Blume (2000) show theoretically how optimization principles may shape the structure of natural languages. On the experimental side, Weber and

[5]Certain contexts might easily explain any gap between the *knowledge* and *use* of B if the B's speech community is economically poor and/or if B has a low status in the society. We do not model such situations. Considering them would reinforce our conclusions.

[6]"Linguistic distance" is a term from linguistics and refers to cases where the communication is only possible in the same language. Thus, no passive bilingualism is allowed. There are many languages around the world, which are in contact and linguistically distant: indigenous languages in the U.S. and English, Quechua and Spanish, Maori and English, Georgian and Russian, Hindi and English, to name a few. This does not apply to e.g. Catalan and Spanish, or Serbian and Croatian contact though. See Crystal (1987).

[7]In some societies, physical traits might signal linguistic types and the assumption of imperfect information would not thus be satisfied. This is the case in some examples in Footnote 4, but not in the examples in the main text.

Camerer (2003) show how organizations develop a private code based on a natural language and Selten and Warglien (2007) study how costs and benefits of linguistic communication shape the emergence of a simple language in a coordination task. Blume and Board (2013) show that large efficiency losses in communication emerge when individuals differ in their language competence and the differences are private information. Recent theoretical contributions by economists dealing with bilingualism include Wickström (2005), Caminal (2010) and Iriberri and Uriarte (2012). To the best of our knowledge, this paper is the first to use the experimental methodology to analyze the language choice.

The remainder of the paper is organized as follows. The following section presents the background and Section 3 describes the experimental design. Section 4 provides the main hypotheses, while Section 5 reports the experimental results. Section 6 explores two experimental phenomena that cannot be explained by the Nash-equilibrium analysis. The last section concludes.

2 Theoretical Background

Consider a society with two official languages A, spoken by every individual, and B, spoken by a minority. Let α and $1-\alpha$ be the proportion of bilingual and monolingual speakers, respectively. To represent the *language contact* situation, we use the Language Conversation Game (LCG, henceforth) proposed by Iriberri and Uriarte (2012). The LCG models the preliminaries of a conversation between two individuals by means of a non-cooperative game in extensive form, in which the languages A and B are the actions available to the players. The purpose of the game is to illustrate how the language used in the actual conversation could be the result of a strategic interaction between two players. Two speech partners, whose linguistic types are private information, interact in a sequential manner. One player, denoted *Player 1*, chooses a language of the conversation. The second player, *Player 2*, observes the choice of Player 1 and selects in which language to reply. To give the minority option good chances, Player 1 can revise her choice if she is bilingual and chose the majority language A in the first stage, but Player 2 replied her using the minority B. In such a case, Player 1 is allowed to switch from A to B. Naturally, the minority B can only be the language of the conversation if both individuals are bilingual; if at least one of them is monolingual, the resulting language is A, independently of other factors.

The game assumes that bilingual speakers are loyal to the minority language B; that is, they prefer to use B in their interactions whenever possible. Thus, the maximum payoff, denoted m, would be obtained when two bilingual speakers coordinate on the minority language B. Since monolingual speakers only speak language A, they make no choice and always receive a payoff $n < m$. Bilingual speakers may also coordinate on the majority language A receiving the payoff equal to n, as long as A was their choice. The reason why we assume that $n < m$ is to illustrate that failure to use the preferred language is likely to occur among bilingual speakers *even* in the presence of payoff incentives to coordinate on B. Last, $n - c > 0$ is the payoff to a bilingual speaker who, having chosen B, uses language A in the actual conversation. The parameter $c > 0$ represents the *frustration cost* of the bilingual speaker "forced" by the interlocutor to switch to A. To ensure the existence of an interior (mixed-strategy) equilibrium, in which bilingual speakers might use their preferred language B with strictly positive probability, we also assume $c < (m - n)\frac{\alpha}{1-\alpha}$ (see Iriberri and Uriarte, 2012).

The proposed framework is more adequate for the study of multilingual societies in high-income countries, where the minority languages are supported by the bilingual minorities, where the statistics about the language literacy are publicly known, and where two linguistically distant languages are in contact. The examples we have in mind are the Basque Country, French Brittany, Ireland, Scotland and Wales. In the Basque Country, the languages are Basque and Spanish in the Spanish part and Basque and French in the French part. In Brittany, Breton competes with the majority French. In the remaining cases, the Gaelic Languages compete with the nowadays *lingua franca*, English. First, the assumption of imperfect information is justified by the type of societies we deal with. Anonymous interactions occur frequently in modern high-income societies due to high mobility of the population, in which bilingual people often engage in interactions where the linguistic type - monolingual or bilingual - of the interlocutor is private information. On the other hand, since the statistics about the knowledge of minority languages are periodically published, we assume common knowledge of α. Second, the loyalty of bilingual speakers to the minority language B (that is, $m > n$) can be justified on economic and political grounds. In most democratic societies, minority languages become co-official because its supporting community is sufficient in number or have enough political power so that the language and the related culture have a high status and prestige for them. It is then natural to assume that members of the speech community would prefer to use B in their interactions. The magnitude of m would measure the intensity of the preference for B. The language distance assumption is necessary to be able to separate the linguistic types and avoids people to understand what is being said in B but answer in A.[8]

Since the interactions between two monolingual individuals always take place in language A, this study focus on the interactions in which at least one individual is bilingual. This restricts our attention onto two types of meetings: bilingual-monolingual and bilingual-bilingual. The former also lead to the use of language A, but the possibility to meet a monolingual individual is necessary to maintain the imperfect-knowledge feature of the LCG.

We view the LCG as a game played by a population of monolingual and bilingual speakers who are randomly matched to interact in pairs. Assuming that the proportion α of bilingual speakers is common knowledge and the size of the population is large, the bilingual speakers believe that they will be matched with another bilingual individual with probability α while with probability $1-\alpha$ they will be matched with a monolingual partner. There are several behavioral plans available to the bilingual speakers in real life. In this paper, we limit our attention to the following two options:

1. $s_{\mathbf{1}}$: *Use always the minoritarian B.*

2. $s_{\mathbf{2}}$: *Use B only when you know for certain that you are interacting with a bilingual individual; use A, otherwise.*

Note that s_1 and s_2 represent two possible strategies of the players in the LCG and they are based on language strategies available in real-life conversations. We discuss them in more details below. There are other options (e.g. use always A or use always A whenever it is known that the interaction partner is bilingual and B otherwise). We do not consider these alternatives in this study, because in the LCG they are all (weakly) dominated by either s_1 or s_2 (see Iriberri and Uriarte, 2012). As a result, the pure-strategy space of each bilingual individual in the game considered in this paper is $S = \{s_1, s_2\}$.

Figure 1 describes the corresponding part of the LCG from the point of view of a bilingual individual: it represents a game with imperfect information, where the matching of two monolingual speakers and the (weakly) dominated strategies of bilingual players have been deleted. Nature first decides the match of the bilingual individual according to probability α. If matched with another bilingual individual, both players play a two-by-two game. Each cell lists the payoffs of the row and column players in lowercase letters (m or n) and the resulting language of the interaction in capital letters (A or B) for the corresponding strategy combination. When

[8] Two linguistically close languages would require a different theoretical framework.

a bilingual speaker meets a monolingual partner, the language of conversation is always A and the payoff is $n - c$ if s_1 is chosen and n under s_2.

Observe that s_1 is a risky option, since a s_1-choosing player can be matched with a monolingual partner, leading to a "forced" use of A, the frustration cost, and the minimum payoff $n - c$. However, s_1 reveals the linguistic type of the player and ensures successful coordination on B and the maximum payoff m in interactions with bilingual opponents.

In contrast, s_2 is risk-free and embodies the sequential nature of the game. It ensures at least n while allowing for the maximum payoff m if a bilingual player is matched with another bilingual player who selects s_1. A s_2-selecting individual starts with action A (if she is Player 1) and only switches to B if she is replied by Player 2 with B (i.e. if Player 2 chooses s_1 in our framework).[9] If the individual is second to move (Player 2) she takes no risk and copies the choice of the partner. Therefore, s_2 represents a safe option, but it is the source of coordination failure: two bilingual B-preferring subjects selecting s_2 will coordinate on the less preferred action A; see Figure 1.

The game in Figure 1 has three equilibria, one stable and two unstable for the associated one-population replicator dynamics (Iriberri and Uriarte, 2012). There exists an interior mixed-strategy Nash equilibrium $x^* = 1 - \frac{c(1-\alpha)}{\alpha(m-n)}$; where x^* denotes the equilibrium proportion of the bilingual speakers playing the strategy s_1. Under the assumptions of the model, $(x^*, 1 - x^*)$ is the only evolutionarily stable equilibrium. This equilibrium can be thought of as a linguistic convention built by the bilingual population (see Weibull, 1995). The game has two additional but unstable pure-strategy equilibria (s_1, s_2) and (s_2, s_1). We focus on the unique stable equilibrium in this study.

3 Experimental Design

We ran five sessions of the experiment in the *Bilbao Laboratory of Experimental Analysis* (Bilbao LABEAN) at the University of the Basque Country in the Spanish part of the Basque Country, where two official languages coexist: Spanish and Basque. Spanish is the majority language in the region spoken by everybody, whereas Basque is the minority language, being 32% the share of bilingual speakers (*V. Inkesta Soziolinguistikoa*, 2012). Two sessions were run in March 2012,

[9] A similar switch occurs in real-life conversations between bilingual speakers. One B-preferring individual for some reason starts a conversation with language A but the speech partner answers in B. It is then natural for the former to switch from A to B and continue the conversation in B.

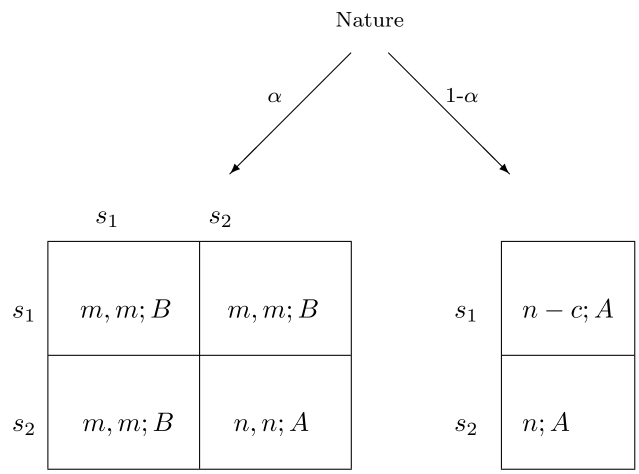

Figure 1: The game played by the bilingual population. With probability α the bilingual player meets another bilingual players and they play the game depicted in the left-hand matrix; with probability $1-\alpha$ the bilingual speaker meets a monolingual one and gets the payoffs from the right-hand table (the monolingual speakers always receive the payoff n). Each cell in the matrix on the left contains three letters: the payoffs of the row and column players, respectively, and the resulting language of the conversation, A or B, in capital letters.

two in March 2013, and one in May 2014. We conducted three sessions in Spanish; two additional sessions were run in Basque. The objective of running treatments in the two languages was to analyze whether the linguistic conditions of subjects precondition their behavior, since bilingual individuals find themselves frequently in real life in a situation similar to the one simulated by our game. Hence, our study can be viewed as an artefactual experiment, i.e. conventional experiment with a nonstandard subject pool (Harrison and List, 2004). A total of 180 students (three sessions with 40 and two session with 30 subjects) were recruited from the undergraduate population of the University of the Basque Country. Each session lasted approximately one hour. The experiment was conducted using the experimental software z-Tree (Fischbacher, 2007). Subjects were given instructions explaining how they could make their choices and how the choices would be reflected in their payoffs.[10] The instructions were read aloud. Subjects were allowed to ask any question they may have had during the whole instruction process. Afterwards, they had to answer six control questions on the computer screen to be able to proceed.

[10]The English translation of the Spanish and Basque instructions can be found in Appendix.

As discussed in Section 2, the experiment focuses solely on the interactions in which at least one of the two participants is bilingual. The experiment consisted of playing 20 or 30 rounds of the LCG depicted in Figure 1. In the first two sessions run in March 2012, subjects played the game for 20 rounds; three 30-period sessions were run in the second and third waves of the experiment to analyze the convergence for a longer time span.[11]

To be able to analyze the net effect of coordination failure, we followed the standard approach in Economics (see Grether and Plott (1984) and Hong and Plott (1982) for early references or Fehr and List (2004) and Palacios-Huerta and Volij (2008, 2009) for more recent examples of artefactual experiments) and designed the experiment as neutral as possible. This is a key aspect of our analysis because in societies where languages are in contact and typically in conflict, bringing languages to the lab might condition participants' behavior to a great extent. Hence, our subjects play a sequential game with a structure similar to a conversation, in which bilinguals may meet monolinguals. No reference to a conversation was made in the instructions and the majority language is labelled as *action A* and the minority language as *action B*. The only parameter found in the field and used in the experiment are the plausible proportions of bilinguals in the population, α. We hope that this design feature allows us to separate the coordination problems from emotional issues attached to language choice in real life.

The main interest lies in the bilingual-bilingual matches, since they allow us to evaluate the extent of the failure to achieve the efficient outcome when two subjects loyal to language B meet. Note that the communication involving at least one monolingual individual always forces the use of the majority A (see Figure 1), but the possibility of monolingual-bilingual matching is important to observe the influence of imperfect knowledge in the experiment. Since monolingual individuals always choose the majority language A, they were simulated by computers. Hence, all experimental subjects play the role of "bilingual" speakers in the actual experiment.[12] In each round, each subject played with another participant of the experiment with probability α, while with probability $1 - \alpha$ she was matched with a computer.

We opted for the strategy method (Brandts and Charness, 2011): participants played without knowing whether they move first (Player 1) or second (Player 2) and had to select the

[11]No time trend is observed from period 20 on in any session. Hence, we do not analyze this issue any further below.

[12]While describing the experimental design and results, we have to be careful distinguishing bilingual players in the game (that is, players who can choose both action A and action B and whose role each participant of the experiment plays) and *true bilingual subjects* in the experiment (i.e. the experimental subjects who speak both Spanish and Basque). To distinguish the two terms, we label the latter as true bilinguals throughout the paper.

complete plan for *any* possible situation in the experiment. In particular, subjects were asked to choose a plan of behavior from the following menu:

1. *Plan 1*: always choose action B.

2. *Plan 2*: play action A unless you know that the other player had played B. More precisely, play A if you are the first to play and switch to B if the second player chooses B; if you are the second player, choose the action the first player started with.

Observe that *Plan 1* and *Plan 2* are equivalent to strategies s_1 and s_2 discussed in the previous section. Hence, Figure 1 depicts the strategic situation faced by each experimental subject. We use the word Plan (rather than strategy) to avoid any technical terminology in the laboratory.

All the participants face the same decision in each round and they were carefully instructed how their choices would determine their experimental payoffs. In each period, the payoffs were determined by the outcome of the game as follows:

- Each subject receives $m = 90$ experimental points (ECU) if the pair coordinates on action B. This happens if two subjects are matched and at least one chooses Plan 1. This payoff cannot be received in any interaction with a computer.

- Each subject receives a payoff of $n = 60$ ECU if the outcome of the game is (A, A). That is, if two experimental subjects meet and both choose Plan 2, or if a participant selects Plan 2 and is matched with a computer.

- If a subject chooses Plan 1 and is matched with a computer, she receives $n - c = 60 - 7 = 53$ ECU. By the design, this payoff can never be received in any interaction with another participant.

The monetary payoffs were expressed in experimental currency units (ECU), converted to Euros at the end of the experiment at the exchange rate of 100 ECU=1 Euro. Subjects earned between 11.4 and 16.3 Euros in the twenty-period sessions and 17.1 and 24 Euros in the thirty-period sessions. The respective averages were 13.6 and 20.1 Euros.

At the end of each round, each participant received the following feedback: her choice (Plan 1 or Plan 2), her position in the timing of the game (first or second/Player 1 or Player 2), the outcome of the game $((A, A), (B, B)$, or $(B, A))$[13], and her payoff.

The sessions differed in two dimensions: the probability of meeting another experimental participant, α, and the language of the experiment (Spanish or Basque). The probability α corresponds to the fraction of bilingual speakers in a large population of the LCG. Three sessions were conducted in Spanish using three different values: $\alpha = 0.2$, 0.4 and 0.6. Two sessions were run in Basque for $\alpha = 0.2$ and $\alpha = 0.6$ ($\alpha = 0.2B$ and $\alpha = 0.6B$, hereafter). We did not run $\alpha = 0.4B$ session, because we detect little differences between the $\alpha = 0.4$ and $\alpha = 0.6$ sessions (see Section 5). Table 1 provides an overview of the treatments and the corresponding numbers of (independent) observations.

	α		
Language	0.2	0.4	0.6
Spanish	40 (800; 4)	30 (900; 3)	40 (800; 4)
Basque	40 (1200; 4)	-	30 (900; 3)

Table 1: Treatments and Number of Subjects (Number of Observations; Number of Independent Observations).

The matching in each round was programmed as follows. First, a share α of participants was randomly selected to play with another participant and once selected, they were randomly paired to play the game. The other participants were matched with a computer that always chooses action A. Whether a subject was matched with a computer or another subject was never revealed to any participant.[14]

At the very end of the experiment and right before the payment, subjects were invited to fill a questionnaire that allows us to control for individual heterogeneity in the statistical analysis.

[13]Remember that the actions taken are determined from the strategies (or plans in the lab terminology) selected, rather than directly decided by the subjects. Note also that (A, B), a participant playing A against someone playing B, cannot occur in the experiment. In such a case, this participant would switch to B by the construction of the strategy s_2 .

[14]Note that the type of the partner can be deduced in some cases. In particular, a coordination on B requires a match with a subject, and choosing Plan 1 and receiving $n - c$ reveals that the subject was matched with a computer. The same information may be deduced in real-life interactions.

4 Hypotheses

We experimentally test three main hypotheses. The first two hypotheses are based on the unique stable equilibrium of the game in Figure 1 (see Section 2):

Hypothesis 1 (*coordination failure*): The rate of coordination on the efficient action B is lower than 100% in the meetings between two participants of the experiment, irrespective of α.

Hypothesis 2 (*effect of* α): The higher the probability of meeting a bilingual individual (α), the lower the extent of coordination failure in the matchings of two experimental subjects.

The third hypothesis is purely behavioral and related to the real-life monolingualism and bilingualism of our experimental subjects. Even though all participants *represent* bilingual individuals in the experiment, the truly bilingual individuals have experience with the language choice in real-life conversations. Do their habits or conventions precondition their behavior in the proposed neutral laboratory framework? There exist large experimental literature on the conflict between risk and payoff dominance showing that in such situations the behavior often converges to the risk dominant options (see Camerer (2003) and Devetag and Ortmann (2007) for reviews). Since strategy s_1 would correspond to the risky option while s_2 maximizes the minimum payoff, we hypothesize the following:

Hypothesis 3 (*true bilingual subjects*): Due to their real-life experience with language choice, the true bilingual subjects choose the maximin strategy s_2 more often than the true monolingual individuals for any α.

5 Experimental Results

This section is divided into three parts. The first describes the overall results of the experiment, the second focuses on matchings of two experimental subjects, while the last one analyzes the effects of the real-life linguistic conditions of participants on their behavior in the two Basque sessions.

5.1 Plan selection

Figure 2 illustrates the evolution of choices in the experiment and the effects of both treatment variables. We plot the fraction of individual choosing the safe Plan 2 on y-axis and the experimental rounds on the x-axis. There is a monotonic association between the choice of Plan 2 and the share α. The pairwise comparisons - contrasting only treatments conducted in the same language - are significantly different in the whole experiment ($p < 0.001$; non-parametric Wilcoxon rank-sum tests) and from round 16 on ($p < 0.003$).[15] In particular, on average 64%, 46.2% and 33.5% of subjects choose the safe Plan 2 for $\alpha = 0.2$, 0.4 and 0.6, respectively, for $t > 15$ in the Spanish sessions; the figures are 75.7 and 33.8% for $\alpha = 0.2B$ and $0.6B$. This ranking is corroborated in the regression analysis and robust to controlling for the effects of experience and individual heterogeneity (see Tables 2 and 3 in Appendix). Hence, these results confirm the Hypothesis 2: higher α induces more subjects to select the risky Plan 1 and thus coordinate on the efficient action B.

The observed percentages are all statistically different from the shares predicted by the mixed-strategy Nash equilibrium x^* ($p = 0$ using $t > 15$; Wilcoxon signed-rank tests). The predicted fractions of bilingual subjects choosing Plan 1 are 6.6%, 65%, and 84.4% for $\alpha = 0.2$, 0.4, and 0.6, respectively. Hence, subjects choose Plan 1 more often than predicted in both $\alpha = 0.2$ sessions whereas less often in all $\alpha > 0.2$ treatments. Section 6 provides a theoretical justification for this regularity.

As for the language of the session, the choice of the safe Plan 2 is more frequent in the Basque session compared to the Spanish one if $\alpha = 0.2$ and $t > 15$ (75.7% vs. 64%; $p = 0.001$). This confirms Hypothesis 3. Truly bilingual subjects more familiar with language choice in real life tend to choose the safer option more often; this in turn results in lower coordination on B. However, the Basque and Spanish sessions are statistically indistinguishable for $\alpha = 0.6$ ($p = 0.945$); 33.7% and 33.5% of subjects select Plan 2, respectively. This contrasts with Hypothesis 3.

The simplest possible test of linear time trends (random-effects logit regression of plan selection over time and α) reveals an increasing trend of selection of Plan 2 over time in both $\alpha = 0.2$ sessions ($p = 0.003$ in both cases); for $\alpha > 0.2$ the estimated time effects are never significant ($p > 0.27$). The trends are significant in no session in the second half of the experiment ($p > 0.56$), suggesting that learning takes mostly place in the initial rounds and that the fraction of subjects playing Plan 2 converges toward a certain level, different for each α (see Figure 2). Therefore, there seems to exist a stable language convention, in which a certain fraction of the population ends up choosing s_1 and "speaking" the minority B (as predicted

[15] Given the differing number of rounds in the treatments, we will only report tests based on rounds after the fifteenth period (i.e. the last five rounds in the twenty-period sessions and the last 15 rounds in the thirty-period sessions). All reported results are identical if we use instead (a) either the second half of the experiment in each treatment or (b) the last five rounds in each treatment.

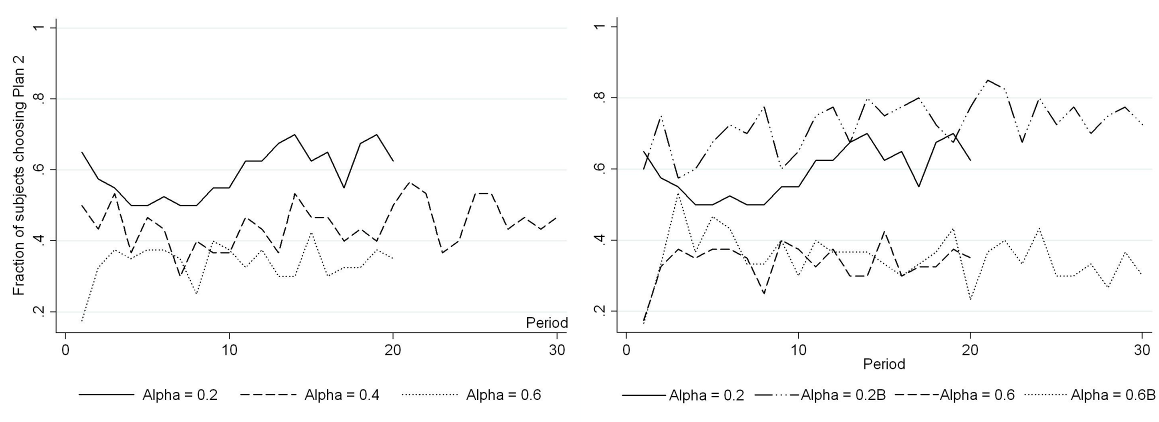

Figure 2: Plan choice over time. *Left*: The effect of α in the Spanish sessions. *Right*: The effect of the language, in which the experiment was run.

by the unique stable equilibrium of the game), even though the theoretical predictions are not confirmed quantitatively. Section 6 shows that the quantitative difference may be explained by bounded rationality.

5.2 Subject-subject interactions

Special interest lies in the meetings of two subjects (representing meetings of two bilingual individuals) that allow to evaluate the extent of coordination failure, since both can and prefer to coordinate on B. In this subsection, we use each subject-subject pair as one unit of observation.

In line with Hypothesis 1, there are large coordination failures. On average, 66.3% (49.2%), 82.8% and 88.3% (88.5%) of subject-subject interactions managed to coordinate on B for $\alpha = 0.2$ ($0.2B$), 0.4 and 0.6 ($0.6B$) respectively in the whole experiment; the corresponding figures are 75% (41.7%), 81.1% and 91.7% (91.9%) if $t > 15$. These figures are different from 100% in all cases if $t > 15$ ($p < 0.03$; Wilcoxon signed-rank tests).[16] All pairwise comparisons between the Spanish sessions go in the expected direction, but the differences are only significant between $\alpha = 0.2$ and $\alpha = 0.6$ at 6% ($p = 0.053$) and between $\alpha = 0.4$ and $\alpha = 0.6$ at 8% ($p = 0.074$); the fraction of coordinated subject-subject pairs between $\alpha = 0.2$ and $\alpha = 0.4$ is statistically indistinguishable ($p = 0.538$). As for the languages of the session, the difference between the two $\alpha = 0.2$ sessions is significant ($p = 0.01$) while the $\alpha = 0.6$ sessions are statistically

[16]The results are even stronger if all rounds are considered ($p = 0$).

indistinguishable ($p = 0.965$).[17]

To provide a more rigorous test, we pool the data for all treatments and control for α, the language of the session, and the time trend using panel-data logit regressions being the dependent variable a dummy for successful coordination on B in each subject-subject pair. Both α ($p = 0$) and the language of the session ($p = 0.022$) affect the extent of coordination, but there is no tendency to learn to coordinate on B over time in these encounters: period is never significant predicting successful coordination ($p = 0.77$).[18] Consequently, the permanent "threat" of being matched with a computer does not allow for better coordination on the efficient outcome over time.

These observations are also reflected in the matches of subjects with computers: subjects matched with a computer chose the risky Plan 1 and thus miscoordinate in 40.2% (27.7%), 53.3%, and 68.4% (63.6%) of cases in the whole experiment in $\alpha = 0.2$ ($\alpha = 0.2B$), 0.4, and 0.6 ($0.6B$), respectively; the corresponding percentages are 33.1% (24.8%), 52.2%, and 65% (63.3%) for $t > 15$.[19]

These results confirm our Hypothesis 1 that if two bilingual individuals meet they do not necessarily coordinate on the minority B. In line with Hypothesis 2, the coordination problem is more severe in populations with low α. Given the neutral, context-free framing of the experiment, we posit that this may partially be attributed to coordination problems present in language selection under imperfect information about the type of the partner.

5.3 Early vs. late bilinguals

The previous subsection provides little evidence in favor of Hypothesis 3. Being monolingual or bilingual does not seem to influence systematically the language choice in our context-free

[17] The differences using all the periods are significant between $\alpha = 0.2$ and both $\alpha > 0.2$ sessions ($p < 0.005$) and between $\alpha = 0.2$ and $\alpha = 0.2B$ ($p = 0.017$). The difference between $\alpha = 0.4$ and $\alpha = 0.6$ is still not significant ($p = 0.105$). The two $\alpha = 0.6$ sessions do not differ ($p = 0.948$).

[18] Similar results are obtained if we include session dummies (instead of controlling for α and the language dummy), except that this alternative specification confirms that the language effect is driven by the $\alpha = 0.2B$ session.

[19] The pooled regression analysis shows that the frequency with which the subjects are forced to use A in the interactions with computers increases in α and decreases over time ($p = 0$; pooled panel-data logit regressions). However, the separate analysis for each treatment again detects a (decreasing) time trend only in the two $\alpha = 0.2$ sessions.

experiment.[20] To test this issue further, we ask our subjects whether their mother tongue is the minoritarian Basque or the majoritarian Spanish. Due to the sociolinguistic conditions in the Basque Country, this information also serves as an index of the age of acquisition of the second language. Virtually everybody speaks Spanish in the region and all participants in the Basque sessions were indeed bilingual. Typically, subjects reporting Basque as the mother tongue learn Spanish simultaneously with the Basque from very early ages in everyday interactions. In contrast, the bilingual participants naming Spanish as the mother tongue have most likely learnt Basque at later stages at school. Following Mechelli *et al.* (2004), we henceforth label the former as *early bilinguals* and the latter as *late bilinguals*.[21] There are respectively 57.5% and 46.7% of early bilinguals for $\alpha = 0.2B$ and $\alpha = 0.6B$.

Figure 3 compares the behavior of the early and late bilinguals in both Basque sessions. We observe that the behavior is more volatile in early rounds than in later stages, suggesting that the behavior of both types of subjects settles over time. With the exception of rounds 9 and 10, early and late bilinguals behave similarly for $\alpha = 0.2B$ till period 20. However, from this period on, the early bilingual subjects tend to select the safe Plan 2 more often. For $\alpha = 0.6B$, late bilinguals choose Plan 2 more often in the first half of the experiment, whereas the early bilinguals choose it more often in the second half of the experiment.

Non-parametric two-sample tests confirm that the early bilingual subjects tend to choose the safer Plan 2 more often in the last 5 ($p = 0.081$ and 0.033 in $\alpha = 0.2B$ and $0.6B$, respectively) and 10 rounds ($p < 0.002$). In contrast, there is no difference between the two groups in the first 5 periods in both sessions or in the first 10 rounds for $\alpha = 0.2B$ ($p > 0.16$). In contrast, the behavior differs statistically in the first 10 rounds for $\alpha = 0.6B$ but in the opposite direction: the late bilinguals choose the safe Plan 2 more often that the early ones initially.[22] Tables 4 and 5 in Appendix report regressions of the plan choice in the two Basque sessions on (i) the early-

[20] This does not mean that there are no behavioral consequences of the differing brain organization between monolingual and bilingual people documented in Mechelli *et al.* (2004). They just do not manifest in our context-free language-choice setup.

[21] In the Spanish sessions, we know the mother tongue of the participants but not whether they are monolingual or bilingual. Since only 5, 1, and 1 subjects stated Basque as the mother tongue in the $\alpha = 0.2$, 0.4, and 0.6 sessions, we cannot perform any meaningful analysis of this issue in the Spanish sessions.

[22] Comparing the early and late bilinguals with the corresponding Spanish sessions uncovers no differences across the people according to their language conditions in the first five rounds ($p > 0.14$), except a marginal difference between the late bilinguals and Spanish-session participants for $\alpha = 0.2$ ($p = 0.093$). Hence, the linguistic condition of participants does not seem to influence the initial play. Most of the differences become significant over time as subjects learn.

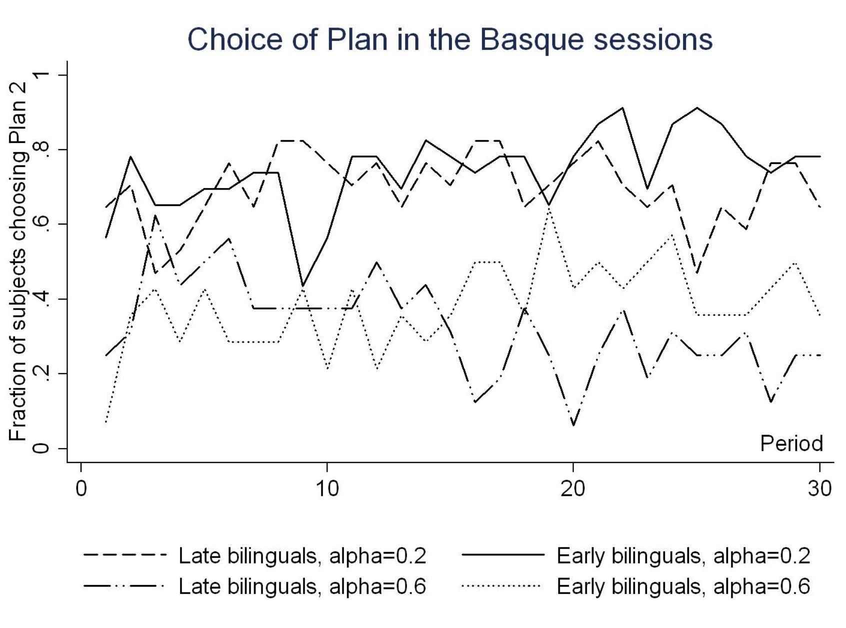

Figure 3: The choices in the Basque sessions, disaggregated for the early and late bilinguals.

bilingual dummy, (ii) period, and (iii) the interaction between period and the early-bilingual dummy, disaggregated for $\alpha = 0.2B$ and $\alpha = 0.6B$. It shows that the differences observed at the end of the experiment come from the evolution of the behavior: the early-bilinguals dummy is rarely significant whereas the interactions between this dummy and period is significant, independently of the specification of the models. The early bilinguals are $e^{0.04} = 1.038$ and 1.073 times more likely to choose the safe option *with each additional period* in the $\alpha = 0.2B$ and $0.6B$, respectively. Hence, the two groups are not different initially but the early bilingual subjects tend to increase the use of the safe Plan 2 over time while the late bilinguals decrease it.[23] Figure 5 in Appendix provides a visualization of the predicted tendencies.

6 Non-equilibrium behavior

The experimental results exhibit two regularities that cannot be explained by the equilibrium analysis of the game in Figure 1: (a) the experimental subjects play the safe Plan 2 more often than predicted by the equilibrium if $\alpha = 0.2$ and less often if $\alpha > 0.2$, and (b) the early

[23]The results are identical if we pool both Basque sessions into one regression.

bilingual individuals learn to choose the safe Plan 2 more often than both the monolingual and late bilingual subjects. Can we find theoretical arguments that would justify these two phenomena?

To answer this question, let us hereafter assume that people are *boundedly rational* and *disappointment averse*. To model the former, we apply the logistic specification of McKelvey and Palfrey's (1999) *quantal response equilibrium* (QRE). Rather than assuming that people play their response with probability one, this approach posits that their behavior is noisy.[24] More precisely, each pure strategy is selected with some positive probability that increases with the expected payoff of the strategy. Hence, more costly mistakes are less likely. The degree of bounded rationality is reflected by a parameter $\lambda \geq 0$. If $\lambda = 0$, people choose randomly; as $\lambda \to \infty$ people become more rational and QRE converges to a Nash prediction. In our game, the QRE converges to the unique stable equilibrium from Section 2.

Additionally, we assume that individuals are averse to disappointment a là Gul (1991). Gul's approach can be understood as one of the reference-dependent models of preferences, in which people compare their payoffs with the certainty equivalents. If the realized payoffs are lower than the certainty equivalent, people suffer disutility proportional to their degree of aversion to disappointment, denoted as β, and the difference between the utility from the outcome and the utility from the certainty equivalent. Formally,

$$U(x) = E[x] - \beta E[\mu - x | \mu > x],$$

where μ is the certain amount that gives the player the same utility as the (uncertain) option x.

Recall that in the unique stable Nash equilibrium each player plays the strategy s_1 with probability $x^* = \max\{0, 1 - \frac{c(1-\alpha)}{\alpha(m-n)}\}$. Under limited rationality, the analogous symmetric equilibrium, in which we assume a common parameter of disappointment aversion, is $x^D = \max\{0, 1 - \frac{c(1-\alpha)(1+\beta)}{\alpha(m-n)}\} \leq x^*$. The following result establishes the relation among the equilibria under the different utility specifications:[25]

Proposition 1 *Assume that each player is averse to disappointment with a parameter $\beta \geq 0$ and $c < (m-n)\frac{\alpha}{1-\alpha}$. Then, in the symmetric logistic Quantal Response Equilibrium of the game in Figure 1, the probability $x^{QRE}(\lambda, \beta)$ of playing strategy s_1 satisfies the following:*

[24]The noise can represent simple mistakes, limited reasoning abilities of players etc.

[25]See Appendix for the proof.

(i) $x^{QRE}(\lambda, \beta) < 1$ *and* $x^{QRE}(\lambda, \beta)$ *increases in* α *for any* $\lambda > 0$ *and* $\beta \geq 0$.

(ii) There exists a threshold $\overline{\alpha}$ *such that* $x^{QRE}(\lambda, \beta) \geq x^D$ *for* $\alpha \leq \overline{\alpha}$ *and* $x^{QRE}(\lambda, \beta) \leq x^D$ *for* $\alpha \geq \overline{\alpha}$ *(with strict inequalities when* $\alpha \lesseqgtr \overline{\alpha}$*).*

(iii) $x^{QRE}(\lambda, \beta)$ *(weakly) decreases in* β *for any* $\lambda > 0$.

(iv) For $\lambda' > \lambda$, $x^D \leq x^{QRE}(\lambda', \beta) < x^{QRE}(\lambda, \beta)$ *if* $\alpha \leq \overline{\alpha}$*, while* $x^D \geq x^{QRE}(\lambda', \beta) > x^{QRE}(\lambda, \beta)$ *if* $\alpha \geq \overline{\alpha}$.

Each part of Proposition 1 provides one insight. Part (i) shows that Hypotheses 1 and 2 still hold in this setup: coordination failure should exist for any α and lower α's should aggravate the coordination problems in equilibrium.

The second part shows that the non-equilibrium regularity (a) can be attributed to bounded rationality: relaxing perfect rationality drives the coordination rates up or down if α lies, respectively, below or above a certain threshold $\overline{\alpha}$. If the aversion to disappointment is not too large, this threshold lies between $\alpha = 0.2$ and $\alpha = 0.4$, matching the behavior observed in the lab. In particular, for our experimental parameters $\overline{\alpha} = 0.32$ if $\beta = 0$ and $\overline{\alpha} < 0.4$ if $\beta < 0.428$.

Part (iii) illustrates the effect of disappointment aversion and relates to why some people may systematically choose s_1 more or less often than others. Particularly, disappointment aversion pushes the number of s_1-choosing individuals down in the equilibrium (be it the fully rational Nash or the boundedly rational QRE). The intuition behind this result is that more disappointment-averse individuals give more weight (with respect to standard utility specifications) to payoff realizations below the certainty equivalent, lowering thus the expected utilities of options that may lead to payoffs below this threshold. Consequently, any model attaching such extra weights to lower payoffs would generate the same effect as disappointment aversion. Examples of such models include risk aversion,[26] regret aversion a là Loomes and Sugden (1982), or the loss aversion with respect to certain reference point (e.g. rank-dependent model of Kőszegi and Rabin, 2006). We selected the linear specification of Gul's (1992) model for the sake of simplicity but any of these alternative models would work too. Hence, Proposition 1 predicts the early bilingual individuals to play the risky Plan 1 less often than the late bilinguals for any α if the former are more averse to disappointment, risk, regret, and/or losses. Is this what we observe in the data?

[26] In fact, Gul (1992) shows that there is a strong link between risk aversion and his disappointment aversion.

We find little support for any of these models in the data.[27] Tables 4 and 5 in Appendix show that the early and late bilinguals exhibit no different reactions to the between-round experience.[28] That is, neither the early nor late bilinguals react differently to disappointing outcomes or outcomes below the rational expectations (e.g. choosing the risky Plan 1 and being miscoordinated), providing indirect evidence against the disappointment or regret aversion, or loss aversion a là Kőszegi and Rabin (2006). Moreover, the difference is unlikely to be due to different reference points, because both types are identical in the early stages of the experiment and only different reactions to the experience would suggest different evolution of the reference points over time. However, we cannot observe the reference points people hold. We also find little support for differing risk aversion between the two types. The early bilinguals are indeed more risk averse in three non-incentivized risk-related questions in the questionnaire but the differences are statistically weak (both testing the differences questions by question, $p > 0.19$, or using the combination of all the variables, $p = 0.304$). Controlling systematically for these variables in the regression analysis does relate with the behavior in the experiment in the expected direction, but affects neither the early bilingual dummy nor the interaction between this dummy and period.[29]

Last, Part (iv) of Proposition 1 rules out two candidate explanations of the documented differences between the early and late bilinguals. First, due to their special linguistic conditions early bilinguals might posses specific cognitive abilities and thus be less or more boundedly rational (systematically higher or lower λ's). Alternatively, one may argue that the early bilinguals may have relatively more experience with a situation simulated in our experiment, suggesting more rational behavior and less mistakes (higher λ's).[30] If one of these arguments lies behind the difference between the two types, then Proposition 1 predicts one type to play the safe Plan 2 more often than the other type above a certain value of α and the contrary below that value. In contrast, the early bilinguals learn to play the safe option systematically more often independently of α.

[27]Since estimating the model parameters for the individual model, jointly with QRE parameter λ, would require additional assumptions, we do not estimate them here and only rely on the indirect evidence.

[28]We also ran regressions including, in addition to the variables used in Tables 4 and 5, the interaction between the early bilingual dummy and the different experience-related variables. These regressions confirm that there are no systematic difference of how each type of bilingual individuals reacts to past experience and the interactions between period and the early bilingual dummy remains significant at these models. We do not report these estimations.

[29]To save on space we do not report the details of these estimations here.

[30]McKelvey and Palfrey (1995) report that experience increases the estimated λ's in the experiments.

In sum, bounded rationality explains why the subjects systematically choose certain options less or more often than predicted and rules out the cognitive- and experience-based explanations of the detected differences between the early and late bilinguals. Indeed, cognitive reflection test and IQ-related questions are unrelated to subjects' play in the regressions and they are no different in these terms. The considered behavioral approaches and risk aversion can tell why some people behave differently than others but we find little support for these theories in the data.

7 Conclusions

This study analyzes whether the failure to speak minority languages may be partially attributed to incomplete information about the linguistic type of speech partners and coordination failure, two phenomena widely studied in economics. To this aim, we simulate experimentally a strategic situation resembling language choice in real-life anonymous interactions, using a context-free framing to be able to isolate the effect of the coordination failure from emotions commonly attached to linguistic issues. We report that the miscoordination on minority languages between people that "speak" the language is persistent and more likely if the language is more minoritarian, more endangered. Moreover, the ability to coordinate on the preferred option in our context-free experiment correlates with real-life linguistic conditions of subjects. Early bilingual subjects (people whose mother tongue is the minoritarian Basque) learn to play the safe, minority language-harming strategies more than other subjects.

Which part of the difference between the knowledge and use of minority languages can be attributed to imperfect information in real life? Figure 4 contrasts our experimental results with real-life language knowledge and use in the in the Spanish part of the Basque Country.[31] The minority-language knowledge, corresponding to α, is measured on the x-axis and its use on the y-axis. The empty circles (full circles/triangles) represent the field (experimental) data. Each dot represents one municipality (treatment) and the y-value is the proportion of the sampled inhabitants of the municipality who took part in a conversation in the minority Basque

[31] This region satisfies the conditions simulated by our experimental design: (i) it belongs to an economically advanced country with high mobility of the population, leading to frequent meetings of unrelated individuals, (ii) it faces a linguistic conflict between two linguistically distant languages, the majoritarian Spanish spoken by everybody and the minoritarian Basque spoken by 32% of the population, and (iii) the survival of the minoritarian language and its co-officiality reflects the loyalty to it.

language (the percentage of the experimental population achieving to coordinate on action B for $t > 15$).[32] The data would lie on the (dashed) 45^o line if all the bilingual individuals in each Basque municipality used the minority Basque in every conversation, something impossible if they interact with non-bilingual individuals. Figure 3 illustrates the discrepancies between the minority-language use and knowledge in real-life, how it varies non-linearly with α, and how the experimental observations match these facts. The figure suggests that the coordination failure may account for a relevant part of the discrepancy. However, due to differing data-collection techniques, we cannot perform rigorous comparison of the field and the experimental observations and thus evaluate quantitatively the relative impact of imperfect-information issues.[33] Most importantly, the real-life meetings are assortative and often far from anonymous (e.g. McPherson et al., 2007), we suspect that Figure 4 exaggerates the relative importance of incomplete information in language choice.

Our findings show that game-theoretical analysis of language choice can inform policies targeting the minority language survival in multilingual societies. Minority languages and their related cultures are in danger of being shifted by the majority language (Fishman, 1991) and the economic literature increasingly recognizes the benefits of linguistic diversity (Ginsburgh and Weber, 2011; Grin et al., 2010). To cope with the enormous power and social presence of the majoritarian languages, only active linguistic policies coupled with bilingual speakers' language behavior may avoid the shifting process of the minority language. This is all the more so when A and B are linguistically distant, since the costs of a language policy to promote B are higher in these cases. There are few particular policy messages. Apart from common policies targeting α through education, the authorities should actively promote the status of minority languages and provide coordination devices that lower the imperfect information.[34] In terms

[32] For example, 75% of subject-subject pairs coordinating on B for $\alpha = 0.2$ and $t > 15$ represents a society, in which 3% (0.75×0.2^2) use the minority language in their conversations if we assume random matching. The percentages are 12.98% and 33.01% for $\alpha = 0.4$ and 0.6, and 1.67% and 33.08% for $\alpha = 0.2B$ and $0.6B$.

[33] The experimental data and the theory are based on pairwise random anonymous interactions and any emotional feelings toward any of the "languages" has been removed. In contrast, the field data are based on language use in randomly chosen conversations on the street, without manipulating the number of participants in each conversation nor who meets with whom. Since all these aspects violate our assumptions, the experimental data may both over- and underestimate the pure effect of coordination failure. The available data do not allow to treat these differences econometrically.

[34] Examples of such devices is the obligation of public employees who interact with the general population to speak the minority languages, documenting and publicizing places, where one can be attended in her language etc.

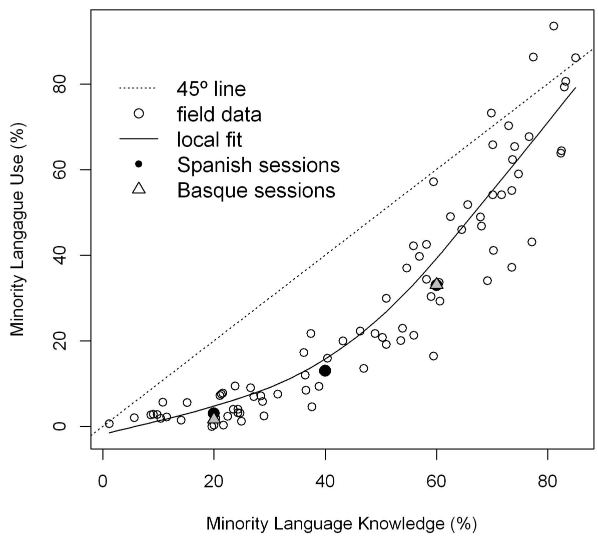

Figure 4: Use and knowledge of the minority Basque language in the Basque Country region of Spain in 2011 and the experimental data. The field data were collected by the Sociolinguistic Cluster (http://www.soziolinguistika.org) in 2011; see Sperlich and Uriarte (2014) for more details. The solid curve is the local polynomial fit on the field data (Cleveland, 1981).

of our model, the former would increase the parameter m whereas the latter promotes the use of the risky strategy s_1. Both aspects have positive impact on the use of B. Moreover, the policies should be designed on basis of the minority-language use rather than their knowledge, as they do not coincide (see Figure 4) as well as in function of the linguistic conditions of bilingual individuals who, it seems, can become discouraged to apply more risky, minority language-promoting behaviors.

There are three directions for further research. First, to better understand the extent of coordination failure in the analyzed situations it is important to complement our laboratory treatment with language choices in natural environments. Second, one may wonder whether the difference between the early and late bilinguals is due to the age at acquisition of the second-language (as suggested by Mechelli et al., 2004) or due to different mother tongue that somehow shapes the behavior (a là Chen, 2013). Third, there are other important socio-economic and psychological factors relevant for the displacement or under-use of minority languages, such as the role of signals, face-to-face interactions, and social networks. We will target these issues in future research.

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Appendix

A Additional results

A.1 Regression analysis

The experimental data constitute a panel, being subjects the cross-sectional variable and rounds the time series. The dependent variable is binary, taking values of zero (one) if a subject in a particular round choose Plan 1 (Plan 2). We estimate random-effect logistic regression models. Four model specifications are used:

1. *Treatment effects* (estimations (1) in Tables 2 and 3): effects of α, a dummy for the Basque session, and controlling for any remaining trends in the data over time (variable *period*).

2. *Treatment effects and history* (estimations (2) in Tables 2 and 3): These models add four variables controlling for individual experience to the specification (1). In particular, we control for whether the last round was miscoordinated or not (*Miscoor.* in the tables), whether coordination occurred after a choice of Plan 1 (*Coord. B & Plan 1*), whether coordination occurred after a choice of Plan 2 (*Coord. B & Plan 2*), and whether the subjects played first (*First*) in the previous round. Hence, the reference category is having chosen the risky Plan 1 and being coordinated.

3. *Treatment effects, history, and individual (time-invariant) heterogeneity* (estimations (3) in Tables 2 and 3): These models, apart from the above, control for heterogeneity from the questionnaires (such as gender, native language, risk aversion, cognitive reflection, social values etc.).

4. *Subjects who state the minoritarian Basque language as the mother tongue (early bilinguals) vs. the remaining participants (late bilinguals) in the Basque sessions* (Table 4 for $\alpha = 0.2B$; Table 5 for $\alpha = 0.6B$): These models explore the differences between the two types of individuals, focusing on the dynamics of their choices and the way they react to previous experience. The different models are structured the same way as the above specifications.

	(1)	(2)	(3)
Period	.01***	.008	.008
	(.005)	(.005)	(.005)
Alpha	-4.51***	-4.32***	-4.25***
	(.70)	(.62)	(.63)
Basque session	0.57**	.53**	.71***
	(.26)	(.23)	(.26)
Miscoor.	-	-.77***	-.75***
		(.10)	(.10)
Coord. B & Plan 1	-	-.38***	-.33***
		(.11)	(.12)
Coord. B & Plan 2	-	.90***	.92***
		(.15)	(.15)
First	-	.05	.03
		(.08)	(.08)
Cons.	1.33***	1.55***	2.01***
	(.33)	(.29)	(.57)
Heterogeneity	No	No	Yes
Obs.	4600	4420	4276
p (model)	0	0	0
LL	-2478	-2314	-2230

Table 2: Random-effects logistic regression: Probability of selecting Plan 2 (using α and a dummy for the Basque sessions). Note: *** - significant at 1%, ** - 5%, * - 10%; Micoord., Coord. B & Plan 1, and Coord. B & Plan 2, and First are laggs from the previous round. The first three denote miscoordination, coordination on B while choosing Plan 1, and coordinating on B while choosing Plan 2; the refence catogory is having chosen Plan 2 and being coordinated on A. The same applies to Tables 3-5.

	(1)	(2)	(3)
Period	.01***	.008*	.008*
	(.005)	(.005)	(.005)
$\alpha = 0.2B$	.79**	.74**	.81**
	(0.38)	(.33)	(.36)
$\alpha = 0.4$	-.94**	-.90**	-1.04***
	(.41)	(.36)	(.37)
$\alpha = 0.6$	-1.52***	-1.45***	-1.50***
	(.39)	(.34)	(.36)
$\alpha = 0.6B$	-1.32***	-1.28***	-1.05***
	(.41)	(.35)	(.38)
Miscoor.	-	-.77***	-.75***
		(.10)	(.10)
Coord. B & Plan 1	-	-.38***	-.33***
		(.11)	(.12)
Coord. B & Plan 2	-	.90***	.92***
		(.15)	(.15)
First	-	.05	.03
		(.08)	(.08)
Cons.	.33	-.59**	1.20**
	(.27)	(.24)	(.53)
Heterogeneity	No	No	Yes
Obs.	4600	4420	4276
p (model)	0	0	0
LL	-2477	-2313	-2230

Table 3: Random-effects logistic regression: Probability of selecting Plan 2 (using session dummies, being $\alpha = 0.2$ the reference group). Note: *** - significant at 1%, ** - 5%, * - 10%.

$\alpha = 0.2B$	(1)	(2)	(3)	(Late bil.)	(Early bil.)	(4)
Early bilinguals	.17	-.39	.33	-	-	-.41
	(0.42)	(.49)	(.45)			(.44)
Period	.02***	.00	.00	.00	.03***	-.01
	(01)	(.01)	(.01)	(.01)	(.01)	(.01)
Early bil. × period	-	.04**	.03*	-	-	.04**
		(.02)	(.02)			(.02)
Miscoor.	-	-	-1.00***	-.93***	-1.06***	-1.01***
			(.17)	(.27)	(.23)	(.18)
Coord. B & Plan 1	-	-	-.49*	-.46	-.50	-.39
			(.30)	(.42)	(.44)	(.30)
Coord. B & Plan 2	-	-	1.53**	1.56	1.52**	1.53**
			(.63)	(1.06)	(.77)	(.62)
First	-	-	-.02	-.40*	.25	-.03
			(.15)	(.24)	(.20)	(.15)
Cons.	.78**	1.11***	1.37***	1.58***	.90***	-.15
	(.34)	(.37)	(.36)	(.42)	(.30)	(1.32)
Heterogeneity	No	No	No	No	No	Yes
Obs.	1200	1200	1160	493	667	1131
p (model)	0.001	0.003	0	0.003	0	0
LL	-627.9	-625.4	-578.4	-247.9	-327.7	-554.4

Table 4: Early vs. late bilingual subjects in the $\alpha = 0.2B$ session. Note: ***1%,**5%,*-10%; testing *period* + *early.bil.*×*period=0* significant at less than 1% in models (2-4).

$\alpha = 0.6B$	(1)	(2)	(3)	(Late bil.)	(Early bil.)	(4)
Early bilinguals	.30	-.96*	-.80	-	-	-.94*
	(.43)	(0.52)	(.50)			(.53)
Period	-.01	.05***	-.06***	-.06***	.02	-.06***
	(.01)	(.01)	(.01)	(.02)	(.01)	(.01)
Early bil. × period	-	.08***	.07***	-	-	.07***
		(.02)	(.02)			(.02)
Miscoor.	-	-	-.77***	-1.18***	-.50	-.77***
			(.24)	(.39)	(.32)	(.24)
Coord. B & Plan 1	-	-	-.33	-.27	-.41	-.33
			(.22)	(.31)	(.31)	(.22)
Coord. B & Plan 2	-	-	.67***	.60	.77**	.67**
			(.26)	(.40)	(.35)	(.26)
First	-	-	-.15	-.10	-.23	-.14
			(.16)	(.24)	(.22)	(.16)
Cons.	-.75**	-.13	.29	.35	-.50	.74
	(.32)	(.36)	(.39)	(.48)	(.38)	(.80)
Heterogeneity	No	No	No	No	No	Yes
Obs.	900	900	870	464	406	870
p (model)	0.484	0	0	0	0.003	0
LL	-530.7	-520.2	-486.6	-235.0	-248.6	-485.4

Table 5: Early vs. late bilingual subjects in the $\alpha = 0.6B$ session. Note: ***1%,**5%,*-10%; testing *period* + *early.bil.*×*period=0* sign. at less than 2% in (1) and not sign. ($p > 0.23$) in (3-4).

A.2 Additional Figure

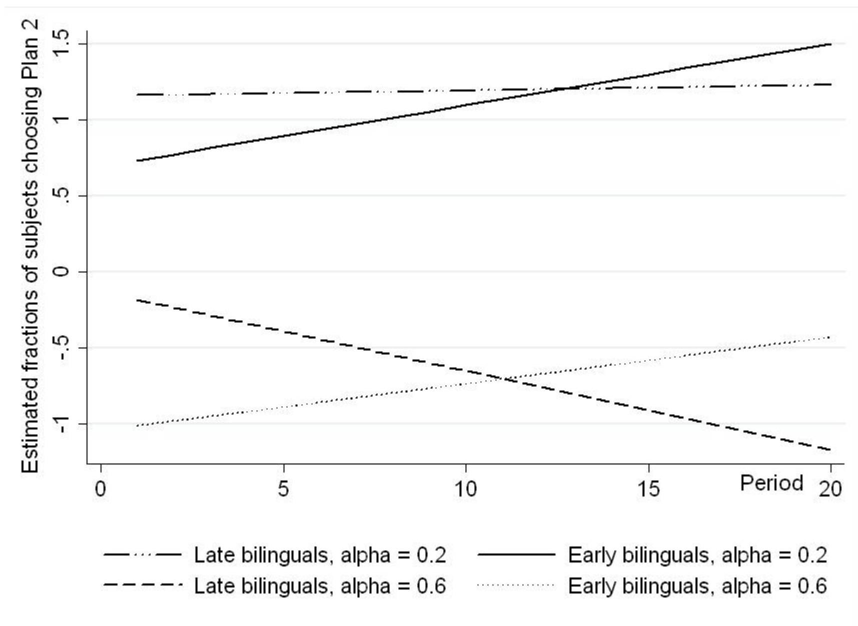

Figure 5: The estimated evolution of behavior in the Basque sessions, disaggregated for the early and late bilinguals. The predictions come from regressing the plan dummy on a constant and period for each group seperately.

A.3 Proof of Proposition 1

Proof. In the symmetric logistic QRE, each player plays s_1 with probability p^*, which is the solution of

$$H(p^*, \lambda, \alpha, \beta) = \frac{e^{\lambda[\frac{\alpha m+(1-\alpha)(1+\beta)(n-c)]}{1+\beta(1-\alpha)}}}{e^{\lambda[\frac{\alpha m+(1-\alpha)(1+\beta)(n-c)]}{1+\beta(1-\alpha)}} + e^{\lambda[\frac{p^*(\alpha m+(1-\alpha)(1+\beta)n)}{1+\beta(1-\alpha)}+(1-p^*)n]}} - p^* = 0, \tag{1}$$

implying $p^* < 1$.

Denote

$$\begin{aligned} A &= e^{\lambda[\alpha m+(1-\alpha)(1+\beta)(n-c)][1+\beta(1-\alpha)]^{-1}} > 0, \\ B &= e^{\lambda[p^*(\alpha m+(1-\alpha)(1-\beta)n)[1+\beta(1-\alpha)]^{-1}+(1-p^*)n]} > 0, \end{aligned}$$

and

$$D = -\frac{\partial H}{\partial p^*} = AB\lambda\alpha(m-n)[1+\beta(1-\alpha)]^{-1}(A+B)^{-2} + 1 > 0.$$

Then,

$$\frac{dp^*}{d\alpha} = -\frac{\partial H(.)/\partial\alpha}{\partial H(.)/\partial p^*} = \frac{\lambda AB(1+\beta)[(1-p^*)(m-n)+c]}{[1+\beta(1-\alpha)]^2(A+B)^2 D} > 0.$$

This proves part (i). To prove part (ii), if $\alpha = 1$, $p^* = \frac{e^{\lambda m}}{e^{\lambda m}+e^{\lambda[p^* m+(1-p^*)n]}} < 1 = x^D$ for any $p^* \in [0,1]$ and, if $\alpha = 0$, $p^* = \frac{e^{\lambda(n-c)}}{e^{\lambda(n-c)}+e^{\lambda n}} > 0 = x^D$. Thus, since both $H(.)$ and x^D are continuous in α, $p^* = x^D$ for *at least* one value of α. Setting $p^* = x^D$ in (1) shows that there is a unique solution, corresponding to $\alpha = \overline{\alpha} = \frac{2c(1+\beta)}{m-n+2c(1+\beta)}$. That is, $p^* = x^D$ if and only if $\alpha = \overline{\alpha}$ and $p^* < (>) x^D$ if $\alpha > (<) \overline{\alpha}$.

As for part (iii), note that

$$\frac{dp^*}{d\beta} = -\frac{\partial H(.)/\partial\beta}{\partial H(.)/\partial p^*} = -\frac{\lambda AB(1-\alpha)\alpha[(1-p^*)(m-n)+c]}{[1+\beta(1-\alpha)]^2(A+B)^2 D} \leq 0$$

with strict inequality for any $\alpha \in (0,1)$.

To prove part (iv),

$$\frac{dp^*}{d\lambda} = -\frac{\partial H(.)/\partial\lambda}{\partial H(.)/\partial p^*} = \frac{[\alpha(1-p)(m-n)-(1-\alpha)(1+\beta)c]AB}{[1+\beta(1-\alpha)](A+B)^2 D} \lesseqgtr 0 \tag{2}$$

if and only if $x^D \lesseqgtr p^*$. Since part (ii) proves that $x^D \lesseqgtr x^{QRE}(\lambda,\beta)$ if and only if $\alpha \lesseqgtr \overline{\alpha}$, (2) implies that $x^{QRE}(\lambda,\beta)$ decreases (increases) with λ if and only if $x^D \lesseqgtr x^{QRE}(\lambda,\beta)$. This finishes the proof. ∎

B Instructions

WELCOME TO THE EXPERIMENT!

This experiment analyzes how people make their choices.

We do not expect from you any particular behavior. Just bear in mind that your choices will affect the amount of money you will earn. However, independently of your behavior you can never loose money.

In the following, you will find instructions of how the experiment works and how you can use the computer during the experiment.

Please, do not talk to other participants of the experiment. If you need any help, raise your hand and one of the experimenter will attend you as soon as possible.

We would also like to ask you to turn off you cell phones and not to use them during the experiment.

THE EXPERIMENT

- The experiment consists of 20 rounds.
- In each of these rounds, you will participate in the game that we explain below.
- In each round, you will be randomly paired either with a computer or with another participant of this experiment.
- You will never know whether you were paired with a computer or a person, neither who that person is in the latter case.
- The amount you earn depends on how you play, with whom you play, and how the other player plays.
- During the experiment, we will use points as a measure of payment, but at the end of the experiment you will be paid the full amount in euros at the exchange of 1 per 100 points (100 points = 1 €).

THE GAME

- In each of the 20 rounds, you will play the same game.

- There are two players in the game. You are one of them. The other player is a computer or a person in this room chosen at random.
- At the end of each round, you will be paired with a new player (computer or participant).
- There are two possible actions in the game: A or B.
- With 60% probability you will be paired with a computer. The computer always plays A.[35]
- With 40% probability you will be matched with someone else from this room and she, like you, can do A or B.
- The game is sequential. The sequence of the game is as follows: one player chooses first; then it is the turn of the second player, after which the former has the option to change her choice.
- The outcome of the game is determined by the final actions of both players.
- In each round, you will play without knowing if you are first or the second. You will not know your position! With probability 0.5 you will choose first and with probability 0.5 you will choose second.

YOUR PARTICIPATION

In each round, your participation consists of choosing in a plan of behavior from 2 options:

1. **Plan 1**: always choose action B.
2. **Plan 2**: play action A unless you know that the other player had played B. More precisely, play A if you are the first to play and switch to B if the second player chooses B; if you are the second player, choose the action the first player started with.

Note that under Plan 1 you choose B regardless of the position you occupy in the game and the other player's choice. However, under Plan 2 you choose A or B depending on the position you occupy in the game and the other player's choice.

[35] Remember that one of the treatment variables is the share of bilingual speakers, α. Hence, the only difference across the treatments concerning the instructions comes from the differing shares. These instructions are from $\alpha = 0.4$.

THE OUTCOME OF THE GAME AND THE PAYOFFS

- If the other player is a computer and you choose Plan 1, the outcome of the game will be A for the computer and B for you. As a result, your payment will be equal to 53 points.
- If the other player is a computer and you choose Plan 2, the outcome of the game will be A for both and your payment will be equal to 60 points.
- If the other player is another person in the room and both of you choose Plan 1, the outcome of the game will be B for both and your payment will be equal to 90 points.
- If the other player is another person in the room who chooses Plan 1 and you choose Plan 2, the outcome of the game will be B for both. So, your payment will be equal to 90 points.
- If the other player is another person in the room who chooses Plan 2 and you choose Plan 1, the outcome of the game will be B for both. So, your payment will be equal to 90 points.
- If the other player is another person in the room and both of you choose Plan 2, the outcome of the game will be A for both. So, your payment will be 60 points.

Summary of payments:

- With probability 40% you will play with another participant the following game:

Plan **You**/Other	Plan 1	Plan 2
Plan 1	**90** , 90	**90** , 90
Plan 2	**90** , 90	**60** , 60

Your payment, your partner's payment

- With probability 60% you will play with a computer (which always plays A) the following game:

Plan **You**/Computer	
Plan 1	**53**
Plan 2	**60**

Your payment

How should the Tables be read?

In the first table (where the other player is another participant), the rows refer to your choice (in bold), Plan 1 or Plan 2, and the columns the choice of the other participant. The first number (in bold) corresponds to your payment, while the second is the payment of the other player.

- If both of you choose Plan 1, the payment will be equal to 90 points for both.
- If both of you choose Plan 2, the payment will be equal to 60 points for both.
- In all other cases, the payment will be 90 points.

In the second table (where your partner is a computer):

- If you choose Plan 1, you will get 53 points.
- If you choose Plan 2, you will get 60 points.

After each round, the screen will show the information about the behavior plan you have chosen, your position (first or second), the outcome of the game, and your payoff.

SUMMARY

- There are 20 rounds.
- In each round, you will be paired at random with another participant (with probability 40%) or with a computer (with probability 60%).
- In each round, you will play without knowing whether you are the first or the second.
- Your decision consists of choosing a behavior plan in each round.
- Two plans are possible:

  1. Plan 1: always choose action B.

2. Plan 2: play action A unless you know that the other player had played B. More precisely, play A if you are the first to play and switch to B if the second player chooses B; if you are the second player, choose the action the first player started with.

- Remember that the computer always chooses A.
- Your payment is 90 points if the outcome of game is B for both, 60 points if the outcome is A for both, 53 points if the outcome of the game is A for you and B for the other.

Control Questions (Please, answer the questions on the computer screen)

1. Imagine that, in one round, you are paired with a computer. What does the computer choose?
   (a) To play always B.
   (b) To play A unless it knows you always choose B.
   (c) To play always A.

2. Plan 1 consists of:
   (a) Playing always B.
   (b) Playing sometimes A and sometimes B.
   (c) Playing always A.

3. If you choose Plan 1 and your partner Plan 2, your payment will be:
   (a) 90.
   (b) 53.
   (c) 60.

4. If you observe that your payment is 90:

(a) your partner is a person.

(b) you cannot know whether your partner is a person or a computer.

(c) your partner is a computer.

5. If you choose Plan 2 and your partner chooses Plan 2, the outcome of the game is:

    (a) The outcome of the game is A for you and B for your partner.

    (b) The outcome of the game is A for both.

    (c) The outcome of the game is B for you and A for your partner.

6. If you choose Plan 1 and your partner chooses Plan 2, the outcome of the game is:

    (a) The outcome of the game is A for you and B for your partner.

    (b) The outcome of the game is B for you and A for your partner.

    (c) The outcome of the game is B for both.