Cognition 173 (2018) 8–15

Contents lists available at ScienceDirect

Cognition

journal homepage: www.elsevier.com/locate/cognit

Original Articles

Using a foreign language reduces mental imagery

Sayuri Hayakawa*, Boaz Keysar

Department of Psychology, University of Chicago, 5848 S. University Ave., Chicago, IL 60637, USA

ARTICLE INFO

Keywords:
Bilingualism
Mental imagery
Foreign language
Morality
Decision making

ABSTRACT

Mental imagery plays a significant role in guiding how we feel, think, and even behave. These mental simulations are often guided by language, making it important to understand what aspects of language contribute to imagery vividness and consequently to the way we think. Here, we focus on the native-ness of language and present evidence that using a foreign language leads to less vivid mental imagery than using a native tongue. In Experiment 1, participants using a foreign language reported less vivid imagery of sensory experiences such as sight and touch than those using their native tongue. Experiment 2 provided an objective behavioral measure, showing that muted imagery reduced accuracy when judging the similarity of shapes of imagined objects. Lastly, Experiment 3 demonstrated that this reduction in mental imagery partly accounted for the previously observed foreign language effects in moral choice. Together, the findings suggest that our mental images change when using a foreign tongue, leading to downstream consequences for how we make decisions.

1. Introduction

Think back to your childhood room: the shape of the window, the color of the walls, where the bed was placed. Now imagine your dream home: the amount of light filtering in and the height of the ceilings. We are equipped with a remarkable ability not only to recreate the past and imagine the future but also to use language to shape and transmit these mental simulations to others. A variety of factors affect the richness of our imagery such as our experiences (Plailly, Delon-Martin, & Royet, 2012) or the concreteness of the language used to describe the event (Paivio, Yuille, & Madigan, 1968). Here, we focus on a novel possibility; namely, that the native-ness of the language may contribute to the vividness of mental imagery. We propose that mental imagery is reduced with the use of a foreign language.

It makes sense that factors such as concreteness of language would affect vividness of imagery. Your image of the shape of the window in your childhood room is more concrete and more vivid than your image of the abstract feeling of safety you might have had in that room. In contrast, it makes little intuitive sense that using a foreign language would reduce mental imagery. If you are told to imagine that *window*, why should it matter if instead you are told to imagine that *ventana*? If you speak Spanish as a foreign language and fully understand that *ventana* means window, the vividness of your image should be determined by your underlying concept of "window" independent of the word used to conjure it up. But there are reasons to believe that in fact, the image of *ventana* would be less vivid than that of *window*.

Using a foreign language may reduce the vividness of mental imagery due to reduced access to sensory memories, which serve as the ingredients for novel mental representations. Imagining novel scenes relies on some of the same processes as imagining the past (Schacter, Addis, & Buckner, 2007). Neuroimaging studies have demonstrated significant overlap in brain activity when participants are cued to picture future and past events (e.g. Addis, Wong, & Schacter, 2007; Okuda et al., 2003; Szpunar, Watson, & McDermott, 2007). Additionally, patients with deficits in episodic memory retrieval also have trouble imagining novel scenes, further suggesting that a common machinery helps us remember events that have happened in the past and imagine those that have not (e.g. Hassabis, Kumaran, Vann, & Maguire, 2007; Tulving, 1985). Similarly, there are reasons to think that using a foreign language may reduce access to memories and may thereby mute mental imagery.

Marian and Neisser (2000) found that episodic memories are *language-dependent*, such that they are more easily recalled when the language in which the memory was encoded matches that of retrieval. When Russian-English bilinguals were asked to recall past events, their ability to recall was dependent on whether they were asked in the language that the event occurred. They were significantly more likely to recall events that took place in a language environment that matched the language of the cue. Memories are also more detailed, numerous and emotional when the language of encoding matches that of retrieval (e.g. Marian & Neisser, 2000; Matsumoto & Stanny, 2006; Schrauf & Rubin, 1998). For most, the majority of memories will have been encoded in the native tongue, and as such may be accessed less fluidly when using the foreign language.

* Corresponding author.
E-mail address: sayuri@uchicago.edu (S. Hayakawa).

https://doi.org/10.1016/j.cognition.2017.12.010
Received 31 January 2017; Received in revised form 16 November 2017; Accepted 14 December 2017
Available online 23 December 2017

If we are correct and using a foreign language does reduce the vividness of mental simulations, this would have important theoretical implications because it could explain why using a foreign language affects the choices that we make (see Costa, Vives, & Corey, 2017; Hayakawa, Costa, Foucart, & Keysar, 2016 for reviews). For instance, using a foreign language has been shown to affect perceptions of risk (Hadjichristidis, Geipel, & Savadori, 2015), self-control (Klesse, Levav, & Goukens, 2015), and moral judgment (e.g. Corey et al., 2017; Costa, Foucart, Hayakawa, et al., 2014; Geipel, Hadjichristidis, & Surian, 2015a). All of these types of choices can be influenced by mental imagery, for instance by making vividly imagined outcomes seem more likely to occur (e.g. Sherman, Cialdini, Schwartzman, & Reynolds, 1985) or making temptations more difficult to resist (e.g. Mischel & Baker, 1975; Tiggemann & Kemps, 2005). In the moral domain, it has been demonstrated that reduced mental imagery leads to more utilitarian behavior when participants are presented with dilemmas such as whether to sacrifice one life to save five (Amit & Greene, 2012). A similar increase in utilitarian behavior has been found when using a foreign language (e.g. Costa, Foucart, Hayakawa, et al., 2014), and may result from a common mechanism.

We therefore hypothesized that the use of a foreign language would diminish the vividness of mental imagery and that this would have consequences for choice. We report the results of three experiments testing these hypotheses. Experiment 1 utilized the shortened form of Betts' Questionnaire Upon Imagery (Sheehan, 1967) to evaluate reported vividness when using a native vs. foreign language. Experiment 2 assessed mental imagery through an objective performance task. Lastly, Experiment 3 examined the relationship between language, visualization, and moral decision-making.

2. General methods

To ensure that the foreignness of language was not confounded with any other demographic or self-selection related variables, participants in all experiments spoke both languages and were randomly assigned to complete the tasks in either their native language or their foreign tongue. Within an experiment, all participants had the same native and foreign languages, but the specific language pairings varied across experiments. Language was always treated as a between-subject variable and the entire experiment, including any instructions and interactions with the bilingual experimenter, were conducted in the assigned language. All materials were translated from English to the target language by a native speaker of the target language. These materials were then back-translated into English by a new translator and then checked for comparability by a native English speaker (Brislin, 1970).

In all experiments, a primary concern is that those using the foreign language may not fully comprehend the materials or may not be eligible based on our predetermined criteria. This is especially the case for our online experiments for which we had less control over the subject population (Experiments 1 & 3). After all, it would not be surprising if those using a foreign language visualize scenes less vividly if they are unable to comprehend the descriptions. As such, we included comprehension checks tailored to each study and decided upon exclusion criteria prior to data collection. Details of each experiment's comprehension check are outlined below. Additionally, prior to collecting data, it was decided that participants would be screened out or excluded if they reported that (1) the target native language was not their native language, (2) the target foreign language was their dominant or native language, or (3) they grew up speaking the foreign language in their homes.

3. Experiment 1: Perceived vividness of mental simulations

As a first step to assess the hypothesis that using a foreign language reduces the vividness of mental imagery or simulations, we randomly assigned participants to complete the widely used shortened form of Betts' Questionnaire Upon Imagery (Sheehan, 1967) in either their native language or a foreign tongue. Participants are asked to mentally simulate a number of different sensory experiences and report how vividly they were able to do so. If using a foreign language reduces the vividness of mental simulations, then those using a foreign language should report less vivid imagery than those using their native tongue.

3.1. Participants and procedure

Data from 359 online participants were included in the analysis. Data from an additional 97 participants were excluded from our analyses for the following reasons: 68 participants were excluded because they had two or more errors when translating five randomly pre-selected items, 21 were excluded because they reported the target foreign language, Spanish, to be their dominant language, and 8 were excluded because they reported that the target native language, English, was not their native language. All included participants were native English speakers who spoke Spanish as a foreign language and did not grow up speaking Spanish at home. On average, participants began learning Spanish at age 20, and the average age at the time of the experiment was 27.6 years old. The majority of participants acquired Spanish through formal classroom schooling. They also reported having spent an average of 6.5 months in a Spanish-speaking country. Participants were asked to rate their language proficiency for both English and Spanish for speaking, listening, writing and reading on a scale from 1 (not at all proficient) to 7 (fully proficient). Average proficiency scores for English and Spanish were 6.91 and 5.04, respectively.

Participants were randomly assigned to complete the experiment in English, the native language (n = 180) or Spanish, the foreign language (n = 179). Participants were then asked to try and mentally simulate 35 different sensory experiences across seven modalities that can be described as visual (e.g. "the sun as it is sinking below the horizon"), auditory (e.g. "the clapping of hands in applause"), tactile (e.g. "sand"), kinesthetic (e.g. "running upstairs"), gustatory (e.g. "salt"), olfactory (e.g. "fresh paint"), and organic (e.g. "a sore throat"). After each statement, participants were asked to rate the vividness of their mental simulations as one of the following options which were coded as 1 through 7: "no image", "very vague and dim", "vague and dim", "not clear, but recognizable", "moderately clear", "very clear" or "perfectly clear". Those in the foreign language condition additionally had an option to select "do not understand" for each item. Any item that received this response was excluded from that participant's analysis.

3.2. Results and discussion

Within each of the modalities, we averaged across the five items to obtain a vividness score for the seven different categories. In order to test the overall effect of language on vividness, we first averaged across the seven modalities to obtain a grand average vividness score for each subject. Vividness was greater for the native language condition (Mdn = 6.09) than the foreign language condition (Mdn = 5.89). A Mann-Whitney U test indicated that the difference was significant (U = 13,602, p = .011, r = 0.135). We then ran seven separate Mann-Whitney U tests for each of the modalities with Bonferroni corrections (α = 0.007). As Fig. 1 shows, those using a foreign language had lower vividness ratings for the Visual (U = 13,437, p = .006, r = 0.144), Auditory (U = 13312.5, p = .004, r = 0.151), Tactile (U = 11,992, p < .001, r = 0.222), and Motor (U = 11,652, p < .001, r = 0.241) modalities. There was a marginal effect of language for the Organic modality (U = 13,995, p = .030, r = 0.115). No effect of Language was found for either the Gustatory (U = 15724.5, p = .692, r = 0.021) or Olfactory (U = 14498.5, p = .101, r = 0.087) modalities. The same pattern of results emerges when utilizing parametric analyses with the different modalities entered as within-subject dependent variables in a repeated-measures ANOVA. We observe a main effect of Modality such that some sensations were easier to simulate than others (F(6,

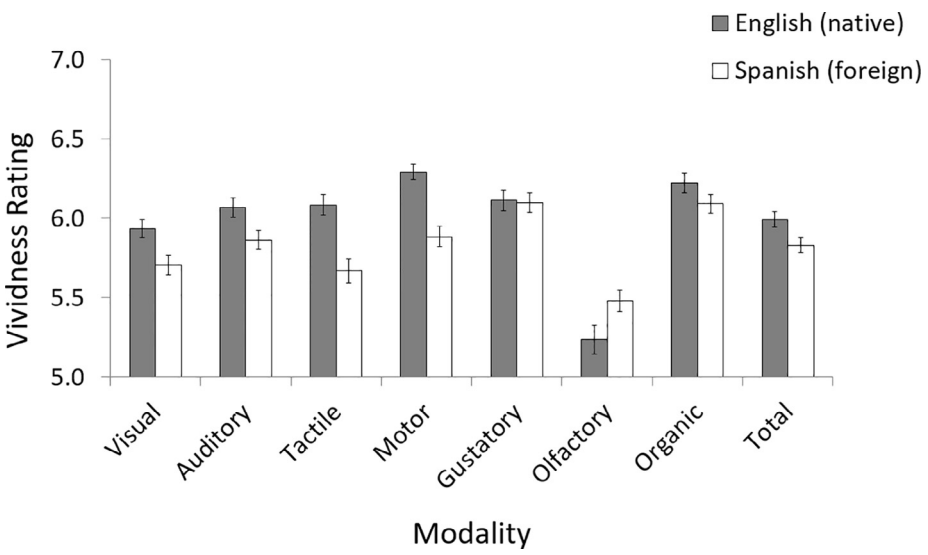

Fig. 1. Average vividness ratings of native and foreign language speakers across different modalities (1 = "no image", 7 = "perfectly clear"). Error bars display standard errors.

2142) = 65.2, p < .001, $\eta^2 = 0.15$), a main effect of Language such that simulations were more vivid in the native language (F(1, 357) = 6.18, p = .013, $\eta^2 = 0.03$) and a Language × Modality interaction, such that the effect of language varied across modalities (F(6, 2142) = 11.59, p < .001, $\eta^2 = 0.02$).[1]

Taken together, the data supports the notion that using a foreign language results in less vivid mental simulations, with varying degrees across different modalities. It is an open question why language seems to affect simulations of some modalities more than others, perhaps with a particular focus on why language did not affect the gustatory and olfactory modalities. Indeed, while not statistically significant, those using the foreign language actually reported numerically greater vividness in the olfactory domain relative to the native tongue. The overall pattern, however, is consistent with the hypothesis that descriptions in a foreign language do not conjure experiences that are as vivid as in a native language. Furthermore, given that the measure was self-report, the results demonstrate that this reduction in vividness was accessible to the participants at a conscious level.

4. Experiment 2: Objective vividness of mental imagery

Experiment 1 demonstrated that using a foreign language reduced the reported vividness of mental simulations. While the data lends support to the theory that using a foreign language diminishes the vividness of mental imagery, it is conceivable that the effect does not reflect actual differences in visualization, but simply the way they are reported. There is evidence that scales may be interpreted differently when using a foreign language such that the poles or labels of scales (e.g. "Joyful") are perceived as less intense in the foreign tongue, resulting in inflated ratings (the "anchor-contraction effect"; De Langhe, Puntoni, Fernandes, & Van Osselaer, 2011). Such an effect would likely lead to reports of increased rather than decreased vividness in a foreign language, but speaks to the potential complications of using self-report measures. In addition, Weijters, Geuens, and Baumgartner (2013) found that scale labels that are more familiar are more likely to be endorsed. To the extent that labels appear less familiar in a foreign language, we might expect less extreme ratings, leading to what appear to be less vivid imagery. Finally, self-report measures of vividness such as the Vividness of Movement Imagery Questionnaire (VMIQ; Isaac, Marks, & Russell, 1986) are not reliably correlated with objective imagery measures (Lequerica, Rapport, Axelrod, Telmet, & Whitman, 2002). As such, the goal of Experiment 2 was to assess whether using a foreign language leads to a reduction in visualization with an objective measure.

4.1. Participants and procedure

Data from 307 participants residing in Beijing, China were included in the analysis. Data from an additional 17 participants were excluded from our analyses for the following reasons: 4 were excluded because they reported the target foreign language, English, to be their dominant language, and 13 were excluded because they reported growing up speaking English at home. All included participants were native Mandarin speakers who spoke English as a foreign language and did not grow up speaking English at home. On average participants began learning English at age 10.22, and the average age at the time of the experiment was 24.59 years old. The majority of participants acquired English through formal classroom schooling. They also reported having spent an average of 6.32 months in an English-speaking country. Participants were asked to rate their language proficiency for both Mandarin and English for speaking, listening, writing and reading on a scale from 1 (not at all proficient) to 7 (fully proficient). Average proficiency scores for Mandarin and English were 6.62 and 4.65, respectively. Participants were randomly assigned to either the native (N = 152) or foreign (N = 155) language conditions.

We used a mental imagery task based on a paradigm introduced by Mehta, Newcombe, and De Haan (1992). Participants were presented with three stimuli and were asked to click on the one that was least like the other two based on a given attribute. For example, a participant could be presented with the words "carrot", "mushroom" and "pen" and be asked to identify which one was least like the other two in terms of its shape, ignoring all other attributes such as size, texture and color (see Fig. 2). In this case, we would expect participants to choose "mushroom". In order to answer this question accurately, participants must visualize the items. Therefore, accuracy on this task served as a measure of how clearly individuals were able to mentally picture the items.

If the use of a foreign language reduces the ability to visualize, then native language users should outperform those using a foreign language. But there might be an alternative explanation to such a finding. Instead of reduced visualization, foreign language users might perform worse because they are not as competent in the language. A person who is unclear about the meaning of "mushroom" would not perform well in

[1] Of the foreign language condition, 69 participants (38.5%) incorrectly translated one of the five preselected comprehension questions. Excluding these participants does not change the pattern of results with the exception that the effect of language on the Auditory modality becomes marginal at the α = 0.007 level (U = 8516.5, p = .045, r = 0.117). All effects remain the same for the parametric analysis.

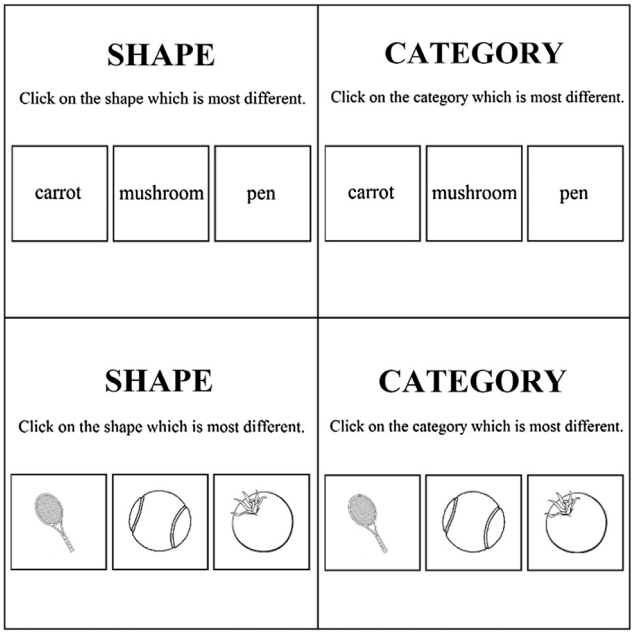

Fig. 2. Example trials from each of the four blocks in the English condition. Clockwise from the top left: Word-Shape, Word-Category, Picture-Category, and Picture-Shape.

this task regardless of mental imagery abilities. In order to control for such effects relating to language competency, we included a second task that required the same level of knowledge of the language but did not rely on visualization. Participants were presented with the same stimuli as in the shape judgment task, but selected the odd item out on the basis of its category membership or function, not on the basis of shape. So for "carrot", "mushroom", and "pen" participants should choose "pen" as the odd one out. This category task should provide a baseline for any deficit induced by the use of a foreign language that is due to language competency such as vocabulary size. We therefore would consider any additional foreign language deficit in the Shape task above and beyond that of the Category task as more directly related to reduced visualization. Participants completed two additional blocks in which the stimuli were simple line drawings that corresponded to the words from the Word blocks, one with a shape judgment and one with a category judgment. This was to ensure that any foreign language effects are indeed due to the language of the stimuli rather than to anxiety that could have been provoked by being in a foreign language environment.

Each participant completed all 4 blocks in a counter balanced order. Each block was made up of 24 trials. For each participant, the same words were used for the Shape and Category tasks, but different stimuli were used for the Word and Picture tasks. In this way, no participant saw a word and a picture that depicted the same item. The assignment of specific stimuli to Word or Picture was counterbalanced across subjects. In order to ensure comprehension, participants were shown each of the Word stimuli again at the end of the experiment and were asked to choose which line drawing matched the word from a set of three pictures. We then excluded any trial from the primary task that utilized a word that was inaccurately matched. The task was conducted on a computer in a quiet lab environment. The entire study took place in the assigned language with a bilingual Mandarin-English speaking experimenter.

If using a foreign language reduces the vividness of mental imagery, then native language users should outperform foreign language users on the Word-Shape task. Critically, this difference should be greater in the Shape task than in the Category task for which less mental imagery is required. This should result in a significant Language × Task interaction for word stimuli. We do not predict such an interaction for picture stimuli. While there might be a general foreign language deficit for pictures due to cognitive load or anxiety, this should be the same for the Shape and Category tasks.

4.2. Results and discussion

4.2.1. Word stimuli analysis

After excluding any Word trials for which participants did not correctly answer the comprehension check, we calculated an accuracy score for each of the two Word blocks. We then ran a repeated measures ANOVA with Language (native vs. foreign) as a between-subject variable and Task (shape vs. category) as a within-subject variable. We found a significant main effect of Language such that those using a foreign language were overall less accurate than those using their native language (Means (SD) = 79.9% (17.4) vs. 93.5% (6.6); $F(1, 305) = 80.11$, $p < .001$, $\eta^2 = 0.208$). Additionally, there was a significant main effect of Task such that participants were more accurate on the Category task than the Shape task (Means (SD) = 92.3% (15.5) vs. 81.1% (19.5); $F(1, 305) = 111.62$, $p < .001$, $\eta^2 = 0.257$). Critically, there was the predicted Language × Task interaction such that the effect of language was greater for the Shape task than the Category task ($M_{difference}$ = 17.9% vs. 9.1%; $F(1, 305) = 17.39$, $p < .001$, $\eta^2 = 0.04$; (see Fig. 3)). This suggests that while there may be some costs to using a foreign language that have to do with the words or vocabulary themselves, there is an additional cost that is related to visualization.

4.2.2. Picture stimuli analysis

For the two Picture blocks, we once again calculated the accuracy score for each task and then ran a repeated measures ANOVA with Language (native vs. foreign) as a between subject measure and Task (shape vs. category) as a within-subject variable. Once again we found a small but significant main effect of Language such that those using their native language outperformed those using their foreign tongue (Ms. 74.3% (5.9) vs. 71.7% (10.9); $F(1, 305) = 7.04$, $p = .008$, $\eta^2 = 0.023$). This suggests that there were indeed some costs to simply being in a foreign language context that hinders performance on even non-linguistic tasks. Unlike for the Word blocks, however, we found no effect of Task (Ms = 72.3% (11.4) for shapes and 73.7% (12.6) for categories; $F(1, 305) = 2.59$, $p = .108$, $\eta^2 = 0.005$), and most importantly, no Language × Task interaction ($M_{difference}$ = 2.6% for shapes and 2.8% for categories; $F(1, 305) = 0.018$, $p = .893$, $\eta^2 < 0.001$; (see Fig. 4)). The fact that there is no interaction with the picture stimuli suggests that the interaction with the word stimuli is specific to processing the language. It rules out the possibility that the interaction for words is due to a general effect of cognitive load or anxiety that a foreign language might induce.

4.2.3. Combined analysis

In order to directly compare whether the Language × Task interaction is significantly different between the Word and Picture blocks, we calculated a Task-Difference Score for each subject by subtracting

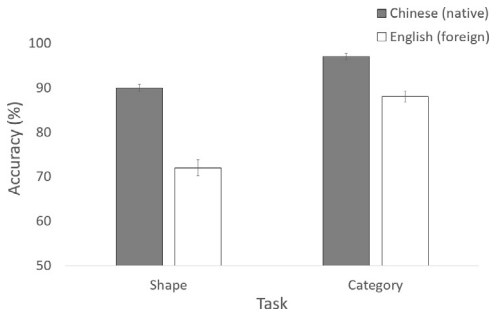

Fig. 3. Average accuracy (%) in the Word blocks for the Shape and Category tasks. Error bars display standard errors.

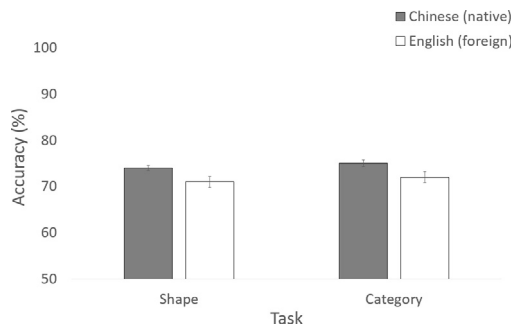

Fig. 4. Average accuracy (%) in the Picture blocks for the Shape and Category tasks. Error bars display standard errors.

their accuracy on the Shape task from the Category task. We then ran a repeated measures ANOVA on the difference score with Language (native vs. foreign) as a between-subject variable and Stimulus Type (word vs. picture) as a within-subject variable. There was a significant main effect of Language such that the difference in accuracy between Shape and Category judgments was larger in the foreign language than the native (Ms = 14.2% (25.6) vs 5.1% (15.9); $F(1, 305) = 58.67$, $p < .001$, $\eta^2 = 0.161$). Additionally, there was a significant main effect of Stimulus Type such that the difference between Shape and Category was greater when presented in Words than in Pictures (Ms = 11.2% (18.9) vs 1.5% (16.1); $F(1, 305) = 62.87$, $p < .001$, $\eta^2 = 0.193$). Critically, there was the predicted Stimulus Type × Language interaction ($M_{difference}$ = 8.8% for words and −0.2% for pictures; $F(1, 305) = 13.76$, $p < .001$, $\eta^2 = 0.042$). This reflects the previous analyses which revealed that using a foreign language was more disruptive for Shape judgments than Category judgments, but only when the stimuli were presented as words.

This experiment used an objective behavioral measure to investigate the vividness of mental imagery. The data reveals that performance on tasks which require mental imagery are especially hindered by the use of a foreign language, suggesting that the vividness of mental imagery may be diminished when using a non-native tongue.

5. Experiment 3: Mental imagery and moral decision making

Experiments 1 and 2 provided support for the idea that using a foreign language reduces the vividness of mental imagery using both self-report and objective measures of visualization. Experiment 3 explores whether this reduction could help explain a previously observed phenomenon that using a foreign language leads to more utilitarian moral behavior.

Imagine you are standing on a bridge overlooking a set of train tracks. You see five people tied to the track and a runaway trolley is barreling towards them. You look to your left and there is a large and heavy man next to you. The only way to stop the trolley would be to push that man off the bridge and on to the tracks, killing the man but saving the five people (Foot, 1978; Thompson, 1985). How vividly can you picture this scene? And does the vividness of your imagination affect your choice? Research suggests that it does. Amit and Greene (2012) found that people are less likely to endorse the utilitarian action of pushing the man off the bridge if they are able to visualize him clearly in their minds. Visual interference that blocks the ability to vividly picture the scene increased the willingness to take the utilitarian, but emotionally aversive, action of sacrificing one life to save many.

When people consider moral dilemmas such as the "Footbridge dilemma" above, those using a foreign language are more willing to sacrifice one person to save five, sometimes as much as twice as likely relative to those using their native tongue (Costa, Foucart, Hayakawa, et al., 2014). This finding has been independently replicated with hundreds of participants across diverse language populations, including speakers of English, Korean, Spanish, French, Hebrew, German and Italian (Cipolletti, McFarlane, & Weissglass, 2016; Corey et al., 2017; Costa, Foucart, Hayakawa, et al., 2014; Geipel et al., 2015a). Despite the accumulating evidence of the effect, little is understood about the underlying processes. One possibility is that using a foreign language increases utilitarian behavior because of reduced mental imagery.

The present study tested this idea by using the classic Footbridge dilemma. If we are correct, then using a foreign language would lead to weaker visualization of the potential victim to be sacrificed compared to using a native language. This should be associated with the willingness to choose the utilitarian option.

5.1. Participants and procedure

Our sample consisted of 800 native German speakers (49% female, M_{age} = 39 years old). Experiment 3 has a large sample size because it was paired with another unrelated experiment involving 8 between-subject conditions. Language was kept constant across experiments, and did not interact with condition assignment from the other experiment for any of the four DVs in the present experiment (decision, single man, five people, overall situation; all $Fs < 1$). Data from an additional 89 participants were excluded from our analyses for the following reasons: 52 participants were excluded for failing to correctly describe the footbridge scenario in their native tongue (German), and 37 participants were excluded because they reported German as their non-dominant language. All participants spoke English as a foreign language and did not grow up speaking English at home. On average participants began learning English at age 14, and the majority of participants acquired English through formal classroom schooling. They also reported having spent an average of 3.59 months in an English-speaking country. Average proficiency scores for German and English were 6.90 and 5.00, respectively.

Participants were randomly assigned to complete the experiment in German (n = 412) or English (n = 388). Participants read the Footbridge dilemma, and responded on a 7-point scale as to whether they would push the man (1 = *definitely would not push him*, 7 = *definitely would push him*). They also rated the vividness of their mental picture of the potential sacrificial victim, the five people who could potentially be saved, and the overall situation. For each one, they could choose between "no image," "very vague and dim," "vague and dim," "not clear, but recognizable," "more or less clear," "very clear," and "absolutely clear image," which were coded as values 1 through 7. The order of the moral decision and the imagery ratings was counterbalanced.

5.2. Results and discussion

We replicated the finding that using a foreign language increases the willingness to endorse pushing the man compared to using a native tongue (Means = 2.41 and 2.15, respectively; $t(797) = 2.04$, $p = .04$, Cohen's $d = 0.14$). Also as predicted and as shown in Fig. 5,

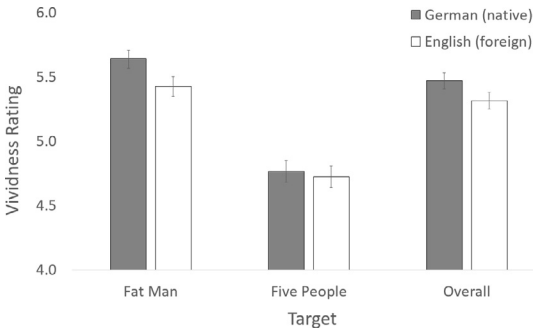

Fig. 5. Average vividness ratings (1–7) for imagining the fat man, the five people, and the overall situation. Error bars display standard errors.

participants rated their visualization of the man as less vivid when using a foreign language than their native tongue ($t(797) = 2.14$, $p = .03$, Cohen's $d = 0.15$). In contrast, there was no difference in the vividness ratings of the five people who could potentially be saved between foreign and native language ($t(798) = 0.37$, $p = .71$, Cohen's $d = 0.03$), and only a marginally significant effect in the ratings of the overall situation ($t(797) = 1.69$, $p = .09$, Cohen's $d = 0.12$). One explanation for this difference may have to do with the salience of the man to be sacrificed. People tend to afford greater weight to individuals than to groups of individuals (Kogut & Ritov, 2005; Redelmeier & Tversky, 1990) and in past research, it is the single individual to be sacrificed, rather than the five people to be saved, that is visualized most vividly and most strongly predicts participants' moral decisions (Amit & Greene, 2012). Research on foreign language effects has demonstrated that they are most likely to emerge for scenarios that are highly emotional or salient in the native language (e.g. Corey et al., 2017; Geipel, Hadjichristidis, & Surian, 2015b). If this is the case, it may help explain why we observe a reduction in vividness for the man to be sacrificed and not the five people, because the former is the most salient part of the scenario.

To evaluate the relationship between imagery and moral judgment, we regressed moral decisions onto the visualization ratings of the single potential victim, the five people to be rescued, and the overall situation. Replicating the findings of Amit and Greene (2012), only vividness ratings of the single potential victim were reliably associated with an unwillingness to push the man ($b = -0.13$, SE = 0.05, $p = .019$). We next conducted a mediation analysis to test whether the reduced vividness of the single potential victim explained the moral foreign language effect. Statistically controlling for vividness ratings of the victim, the effect of language on willingness to sacrifice is reduced to marginal significance ($b = 0.24$, SE = 0.13, $p = .056$). Using bootstrapped bias-corrected confidence interval estimates based on 5000 resamples (MacKinnon, Lockwood, & Williams, 2004; Preacher & Hayes, 2004), we find that vividness ratings of the single victim reliably mediated the effect of a foreign language (indirect coefficient $b = 0.018$; 95% CI [0.00, 0.055]). In our data, vividness ratings of the single victim statistically explained 7% of the treatment effect that foreign language use had on participants' moral judgment. Thus, visualization ratings appeared to play a small but reliable role in explaining the foreign language effect, suggesting that foreign language use affects moral judgment partly by inhibiting mental visualization of the potential victim to be sacrificed.

6. General discussion

We have demonstrated that using a foreign language reduces the vividness of mental imagery. Experiment 1 revealed that the subjective experience of vividness is reduced in a foreign language. Furthermore, the data suggests that this reduction in vividness is not specific to visual imagery, but affects a range of modalities including auditory, tactile and motor simulations. Experiment 2 showed that this reduction in mental imagery extends beyond subjective impressions and is reflected in objective performance measures. These two studies provide the first indication that using a foreign language changes our mental simulations.

Experiment 3 went beyond exploring the effect of language on imagery to examine its consequences for cognition and behavior. It demonstrated that the reduction in the vividness of imagery partially explains why people using a foreign language make more utilitarian choices when faced with moral dilemmas. This finding is complementary to the leading explanation for why using a foreign language might increase utilitarian moral responding: that using a foreign language is less emotional than using a native tongue (e.g. Harris, Aycicegi, & Gleason, 2003; Pavlenko, 2005). Past research has suggested that relying on more emotional or intuitive processes may encourage participants to adhere to deontological rules such as "do no harm" while more deliberative, analytical processes may favor utilitarian decisions which maximize the greater good (e.g., Cushman, 2013; Greene, Morelli, Lowenberg, Nystrom, & Cohen, 2008). While more work is needed to definitively establish the mechanism, a foreign language reduction in emotion could explain why people seem more willing to ignore prohibitions against actively causing harm, and thus are more likely to make the utility-maximizing choice to sacrifice one person for the greater good. Our present findings dovetail with this explanation, as mental imagery is known to be a powerful factor in the experience of emotion (e.g. Dadds, Hawes, Schaefer, & Vaka, 2004; Dickert, Sagara, & Slovic, 2011; Holmes & Mathews, 2005).

Our understanding of the various foreign language effects may thus benefit from empirical tests of whether the reduction in the vividness of mental imagery partially explains why foreign languages are experienced as less emotional. Past research has identified factors such as the context of foreign language acquisition (Harris, Gleason, & Aycicegi, 2006) and the amount of experience with and exposure to foreign language words (Puntoni, De Langhe, & Van Osselaer, 2009) as contributing factors in determining the emotional resonance of the foreign language. Here, we propose that mental imagery may serve as an intermediate step in explaining why reduced familiarity with foreign words or contexts could translate to muted emotional responses.

We have argued that the use of a foreign language reduces vividness because it limits access to episodic memories. However, other potential explanations are possible. One such account may involve cognitive load and working memory rather than access to episodic memory. In order to create mental images, individuals are required to not only recall exemplars, but must be able to flexibly recombine and reconstruct memories in order to create novel representations (Schacter et al., 2007). If such manipulations and retrieval require working memory resources, limiting such resources would likely result in some deficit. Indeed, it has been found that cognitive load reduces the vividness of mental imagery (e.g. Baddeley & Andrade, 2000; Shiv & Huber, 2000). To the extent that using a foreign language is more cognitively taxing, it may restrict the resources available to conjure and construct vivid mental experiences. While this account is possible, our experiments are not fully consistent with it. In Experiment 3, an increase in load with a foreign language would have predicted a decrease in utilitarian responses (Greene et al., 2008). The fact that a foreign language resulted in an increase argues that reduced vividness was induced by reasons other than increase in mental load.

To the extent that the effect of imagery generalizes beyond moral choices, this finding gives way to a number of novel hypotheses regarding how using a foreign tongue could affect decision-making. For example, people are more generous towards a single victim than towards a group of victims (Kogut & Ritov, 2005). This "Identified Victim Effect" is partly due to a greater ease of creating an image of the single victim. To the extent that using a foreign language generates less vivid mental imagery, we may expect a general decrease in helping behavior and/or less differentiation between the normally highly imageable single victim and the less vivid group.

Prior research has also demonstrated that events that are easily or vividly imagined are often perceived as subjectively more likely to occur (e.g. Gregory, Cialdini, & Carpenter, 1982; Sherman et al., 1985). If using a foreign language reduces the ease or vividness of mental imagery generation, it may affect perceptions of probability and likelihood. Relatedly, it has been demonstrated that risk perceptions and willingness to take risks are affected by the intensity of mental imagery regarding potential negative consequences (Traczyk, Sobkow, & Zaleskiewicz, 2015). If using a foreign tongue reduces the vividness of such visualizations, it could help explain previously observed effects such as how using a foreign language decreases risk perceptions (Hadjichristidis et al., 2015) and increases willingness to take risks (Costa, Foucart, Arnon, Aparici, & Apesteguia, 2014; Keysar, Hayakawa, & An, 2012). Importantly, future research should explore the effect of language and imagery in more ecologically valid contexts

to better understand the generalizability of the effects to real world situations such as those involving medical or legal decisions.

Lastly, future work may benefit from a systematic examination of whether the present findings vary as a function of particular languages. In the present set of studies, we consistently found that using a foreign language reduced mental imagery despite the relatively heterogeneous language backgrounds of the groups, from native English speakers speaking Spanish, native Mandarin speakers speaking English, to native German speakers speaking English. This suggests that the present results are not the result of a specific language and are robust across potentially different levels and types of exposure to the foreign language. That said, there is some indication that proficiency may play a role. While we did not find notable proficiency effects for Experiments 2 and 3, in Experiment 1, we find that foreign language proficiency moderates the language effect on imagery for the auditory ($B = -0.19$, $SE = 0.09$, $p = .035$) and motor modalities ($B = -0.22$, $SE = 0.08$, $p = .007$). In these cases, the effect of language is most pronounced for lower proficiency participants. This raises the possibility that proficiency and other aspects of linguistic experience may affect how much people's imagery changes as a function of language. Additionally, it is possible that other factors such as culture could play a role as language has been shown to prime beliefs, norms, and behaviors consistent with the associated culture (e.g. Benet-Martínez, Leu, Lee, & Morris, 2002). For instance, it may be the case that imagery for olfactory and gustatory stimuli were not reduced with a foreign language in Experiment 1 because the foreign language, Spanish, may have primed rich associations of flavorful Mediterranean cuisine. Note that such a mechanism would be independent of the foreign language effect but could exert a different, and sometimes opposite, influence on the vividness of imagery. In general, cultural associations induced by a foreign language could very well interact with its effect on vividness of imagery.

Over the last few years, there has been growing evidence that the use of a foreign language affects many aspects of our experiences ranging from emotional responding to decision-making. Here we provide some evidence that such phenomena may occur because the world imagined through a foreign language is less vivid than through a native tongue.

Author contributions

Both authors contributed to the study concept and design. Data collection & analysis was performed by S. Hayakawa. Both authors contributed to manuscript preparation and approved the final version of the manuscript for submission.

Acknowledgments

The authors thank Leigh Burnett, Rendong Cai, and David Tannenbaum for comments on the manuscript. We also thank Zhenying Tian, Angel Wang, Xinyu Wei, and Ka Ying Becky Lau for technical assistance. This project was supported by a grant from the University of Chicago's Wisdom Research Project and the John Templeton Foundation, and a grant by the National Science Foundation #1520074 to the University of Chicago.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.cognition.2017.12.010.

References

Addis, D. R., Wong, A. T., & Schacter, D. L. (2007). Remembering the past and imagining the future: Common and distinct neural substrates during event construction and elaboration. *Neuropsychologia, 45*(7), 1363–1377.

Amit, E., & Greene, J. D. (2012). You see, the ends don't justify the means visual imagery and moral judgment. *Psychological Science, 23*(8), 861–868.

Baddeley, A. D., & Andrade, J. (2000). Working memory and the vividness of imagery. *Journal of Experimental Psychology: General, 129*(1), 126–145.

Benet-Martínez, V., Leu, J., Lee, F., & Morris, M. W. (2002). Negotiating biculturalism cultural frame switching in biculturals with oppositional versus compatible cultural identities. *Journal of Cross-Cultural Psychology, 33*(5), 492–516.

Brislin, R. W. (1970). Back-translation for cross-cultural research. *Journal of Cross-cultural Psychology, 1*, 185–216.

Cipolletti, H., McFarlane, S., & Weissglass, C. (2016). The moral foreign-language effect. *Philosophical Psychology, 29*(1), 23–40.

Corey, J. D., Hayakawa, S., Foucart, A., Aparici, M., Botella, J., Costa, A., & Keysar, B. (2017). Our moral choices are foreign to us. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 43*(7), 1109–1128.

Costa, A., Foucart, A., Arnon, I., Aparici, M., & Apesteguia, J. (2014). "Piensa" twice: On the foreign language effect in decision making. *Cognition, 130*(2), 236–254.

Costa, A., Foucart, A., Hayakawa, S., Aparici, M., Apesteguia, J., Heafner, J., & Keysar, B. (2014). Your morals depend on language. *PLoS ONE, 9*(4), e94842.

Costa, A., Vives, M. L., & Corey, J. D. (2017). On language processing shaping decision making. *Current Directions in Psychological Science, 26*(2), 146–151.

Cushman, F. (2013). Action, outcome, and value a dual-system framework for morality. *Personality and Social Psychology Review, 17*(3), 273–292.

Dadds, M., Hawes, D., Schaefer, B., & Vaka, K. (2004). Individual differences in imagery and reports of aversions. *Memory, 12*(4), 462–466.

De Langhe, B., Puntoni, S., Fernandes, D., & Van Osselaer, S. (2011). The anchor contraction effect in international marketing research. *Journal of Marketing Research, 48*(2), 366–380.

Dickert, S., Sagara, N., & Slovic, P. (2011). Affective motivations to help others: A two-stage model of donation decisions. *Journal of Behavioral Decision Making, 24*(4), 361–376.

Foot, P. (1978). *The problem of abortion and the doctrine of the double effect in virtues and vices.* Oxford: Basil Blackwell.

Geipel, J., Hadjichristidis, C., & Surian, L. (2015a). The foreign language effect on moral judgment: The role of emotions and norms. *PLoS ONE, 10*(7), e0131529.

Geipel, J., Hadjichristidis, C., & Surian, L. (2015b). How foreign language shapes moral judgment. *Journal of Experimental Social Psychology, 59*, 8–17.

Greene, J. D., Morelli, S. A., Lowenberg, K., Nystrom, L. E., & Cohen, J. D. (2008). Cognitive load selectively interferes with utilitarian moral judgment. *Cognition, 107*(3), 1144–1154.

Gregory, W. L., Cialdini, R. B., & Carpenter, K. M. (1982). Self-relevant scenarios as mediators of likelihood estimates and compliance: Does imagining make it so? *Journal of Personality and Social Psychology, 43*(1), 89–99.

Hadjichristidis, C., Geipel, J., & Savadori, L. (2015). The effect of foreign language in judgments of risk and benefit: The role of affect. *Journal of Experimental Psychology: Applied, 21*(2), 117–129.

Harris, C. L., Aycicegi, A., & Gleason, J. B. (2003). Taboo words and reprimands elicit greater autonomic reactivity in a first language than in a second language. *Applied Psycholinguistics, 24*(04), 561–579.

Harris, C. L., Gleason, J. B., & Aycicegi, A. (2006). When is a first language more emotional? Psychophysiological evidence from bilingual speakers. *Bilingual Education and Bilingualism, 56*, 257–283.

Hassabis, D., Kumaran, D., Vann, S. D., & Maguire, E. A. (2007). Patients with hippocampal amnesia cannot imagine new experiences. *Proceedings of the National Academy of Sciences, 104*(5), 1726–1731.

Hayakawa, S., Costa, A., Foucart, A., & Keysar, B. (2016). Using a foreign language changes our choices. *Trends in Cognitive Sciences, 20*(11), 791–793.

Holmes, E. A., & Mathews, A. (2005). Mental imagery and emotion: A special relationship? *Emotion, 5*(4), 489–497.

Isaac, A., Marks, D. F., & Russell, D. G. (1986). An instrument for assessing imagery of movement: The Vividness of Movement Imagery Questionnaire (VMIQ). *Journal of Mental Imagery, 10*(4), 23–30.

Keysar, B., Hayakawa, S. L., & An, S. G. (2012). The foreign-language effect thinking in a foreign tongue reduces decision biases. *Psychological Science, 23*(6), 661–668.

Klesse, A. K., Levav, J., & Goukens, C. (2015). The effect of preference expression modality on self-control. *Journal of Consumer Research, 42*(4), 535–550.

Kogut, T., & Ritov, I. (2005). The "identified victim" effect: An identified group, or just a single individual? *Journal of Behavioral Decision Making, 18*(3), 157–167.

Lequerica, A., Rapport, L., Axelrod, B., Telmet, K., & Whitman, R. (2002). Subjective and objective assessment methods of mental imagery control: Construct validations of self-report measures. *Journal of Clinical and Experimental Neuropsychology, 24*(8), 1103–1116.

MacKinnon, D. P., Lockwood, C. M., & Williams, J. (2004). Confidence limits for the indirect effect: Distribution of the product and resampling methods. *Multivariate Behavioral Research, 39*(1), 99–128.

Marian, V., & Neisser, U. (2000). Language-dependent recall of autobiographical memories. *Journal of Experimental Psychology: General, 129*(3), 361–368.

Matsumoto, A., & Stanny, C. (2006). Language-dependent access to autobiographical memory in Japanese-English bilinguals and US monolinguals. *Memory, 14*(3), 378–390.

Mehta, Z., Newcombe, F., & De Haan, E. (1992). Selective loss of imagery in a case of visual agnosia. *Neuropsychologia, 30*(7), 645–655.

Mischel, W., & Baker, N. (1975). Cognitive appraisals and transformations in delay behavior. *Journal of Personality and Social Psychology, 31*(2), 254–261.

Okuda, J., Fujii, T., Ohtake, H., Tsukiura, T., Tanji, K., Suzuki, K., ... Yamadori, A. (2003). Thinking of the future and past: The roles of the frontal pole and the medial temporal lobes. *Neuroimage, 19*(4), 1369–1380.

Paivio, A., Yuille, J. C., & Madigan, S. A. (1968). Concreteness, imagery, and

meaningfulness values for 925 nouns. *Journal of Experimental Psychology, 76*(1p2), 1–25.
Pavlenko, A. (2005). Bilingualism and thought. In *Handbook of bilingualism: Psycholinguistic approaches* (pp. 433–453).
Plailly, J., Delon-Martin, C., & Royet, J. P. (2012). Experience induces functional reorganization in brain regions involved in odor imagery in perfumers. *Human Brain Mapping, 33*(1), 224–234.
Preacher, K. J., & Hayes, A. F. (2004). SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods, Instruments, & Computers, 36*(4), 717–731.
Puntoni, S., De Langhe, B., & Van Osselaer, S. M. (2009). Bilingualism and the emotional intensity of advertising language. *Journal of Consumer Research, 35*(6), 1012–1025.
Redelmeier, D. A., & Tversky, A. (1990). Discrepancy between Medical Decisions for Individual Patients and for Groups. *Preference, Belief, and Similarity,* 887–893.
Schacter, D. L., Addis, D. R., & Buckner, R. L. (2007). Remembering the past to imagine the future: The prospective brain. *Nature Reviews Neuroscience, 8*(9), 657–661.
Schrauf, R. W., & Rubin, D. C. (1998). Bilingual autobiographical memory in older adult immigrants: A test of cognitive explanations of the reminiscence bump and the linguistic encoding of memories. *Journal of Memory and Language, 39*(3), 437–457.
Sheehan, P. W. (1967). A shortened form of Betts' questionnaire upon mental imagery. *Journal of Clinical Psychology, 23*(3), 386–389.
Sherman, S. J., Cialdini, R. B., Schwartzman, D. F., & Reynolds, K. D. (1985). Imagining can heighten or lower the perceived likelihood of contracting a disease the mediating effect of ease of imagery. *Personality and Social Psychology Bulletin, 11*(1), 118–127.
Shiv, B., & Huber, J. (2000). The impact of anticipating satisfaction on consumer choice. *Journal of Consumer Research, 27*(2), 202–216.
Szpunar, K. K., Watson, J. M., & McDermott, K. B. (2007). Neural substrates of envisioning the future. *Proceedings of the National Academy of Sciences, 104*(2), 642–647.
Thompson, J. J. (1985). Double effect, triple effect and the trolley problem: Squaring the circle in looping cases. *Yale Law Journal, 94*(6), 1395–1415.
Tiggemann, M., & Kemps, E. (2005). The phenomenology of food cravings: The role of mental imagery. *Appetite, 45*(3), 305–313.
Traczyk, J., Sobkow, A., & Zaleskiewicz, T. (2015). Affect-laden imagery and risk taking: The mediating role of stress and risk perception. *PLoS ONE, 10*(3), e0122226.
Tulving, E. (1985). Memory and consciousness. *Canadian Psychology/Psychologie Canadienne, 26*(1), 1–12.
Weijters, B., Geuens, M., & Baumgartner, H. (2013). The effect of familiarity with the response category labels on item response to Likert scales. *Journal of Consumer Research, 40*(2), 368–381.