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To *stay*, *remain* or *leave*: how verbal concepts as response options in political referendums such as the Brexit polls might bias voting outcomes

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Referendums allow people to participate in political decision-making. However, they also come with the challenge of presenting complex issues to the electorate in a concise and comprehensible way. In order to simplify the decision-making process, referendum questions are often tailored to *yes/no* response options. In comparison, the UK European Union membership referendum of 2016, in contrast to the 1975 referendum on the same issue, discarded this option, and a verbal and conceptually more complex alternative response option was brought into play (*remain* vs. *leave*). This potentially relevant change in the voting tradition justifies a linguistic consideration of the suitability of the choice of verbs. Verbal response options such as *stay*, *remain* and *leave* might activate different framing effects due to their underlying etymology. Our goal was therefore to examine whether the choice of verbs can have a biasing effect, which might be the case due to their frame-inherent structure. This investigation attempts, through both a linguistic analysis and an experimental analysis using a version of the Implicit Association Test (IAT), to bridge the research gap between the awareness that there are linguistic factors that can influence decision-making processes and the lack of inclusion of framing effects. Overall, the data of two IAT studies ($n = 185$ and $n = 355$) suggest that the exact wording of dichotomic response options has the potential to influence response choice based on evaluative associations of the verbs. Specifically, when compared to *leave*, we found relatively more positive evaluation for *stay* than for *remain*. Furthermore - independent of the Brexit referendum - our study raises the question whether verbs are at all suitable to replace *yes/no* response options due to inherent framing effects. This linguistic aspect requires more attention in the design of response options in future referendums.

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Introduction

Referendums are one of the main collective decision-making instruments of modern democracies. They allow people to participate in political decision-making, but they also entail the challenge to present complex issues in a comprehensible and concise way. To be suitable for politics, the wording of the question must not only be easy to understand and to the point, but also phrased unambiguously and neutrally (Electoral Commission 2015).

The two important European Union membership referendums in the United Kingdom, those of 1975 and 2016, differ fundamentally in their linguistic structure regarding their possible response options. While in 1975, the usual *yes/no* choice was available for voting, in 2016 voters had to choose between two verbs: *remain* vs. *leave*. The 2016 poll results revealed that 51.89% of the voters opted for the checkbox answer *leave* (*the European Union*) and 48.11% for *remain* (*a member of the European Union*) when asked the question *Should the United Kingdom remain a member of the European Union or leave the European Union?* (Fig. 1).

In 1975, however, 67.2% of the respondents answered *yes* when asked the question *Do you think that the United Kingdom should stay in the European Community (the Common Market)?* In this case, not only the possibility to choose between *yes* and *no* was different, but also the wording of the question, since only one verb—*stay*—was used. This substantial change in the voting tradition justifies a linguistic consideration of the suitability of the choice of verbs in general in a referendum and the neutrality of the formulations used in the 2016 question.

Previous studies have dealt intensively with the requirements of questioning in decision-making processes and have shown how micro deviations in the formulation of questions can lead to large variations in the response (cf. section “Theoretical and Linguistic Background”). Since studies in the area of response options have been lacking up to now, we examine in the following potential framing effects of replacing the neutral *yes/no* response option with a heterogeneous (static vs. dynamic) verbal alternative (*remain/leave*).

Even though the Brexit vote served us as a case study, since two very different votes were held on a substantively comparable issue within less than 50 years, it is important to emphasise that the focus of our study is not the question of whether the choice of words in the referendum text could have influenced the voters’ decision in any way. For this reason, we have also deliberately refrained from analysing the entire Brexit referendum campaign.

The present study aimed much more at taking a look at framing effects, independent of the topic, that can occur when

different or even heterogeneous, but logically equivalent verbs are used as a substitute for a *yes/no* question. The goal was to examine the extent to which verbs can be suitable as alternative answers or whether their use should be limited to the formulation of questions, due to their frame-inherent structure. This is even more important if we consider that decision-making processes are not uncommon on a political level. Therefore, it is vital to understand how either choosing certain verbs or raising a neutral *yes/no* question might influence voting behaviour. In the present study we examined whether the concepts *remain* and *stay* have equivalent evaluative structures when being used in combination with *leave*.

We assumed that due to the different underlying etymological roots of these verbs, which might unconsciously activate different framing effects, we might find divergent evaluative structures. To investigate the potentially unconscious, or “implicit”, framing effects associated with these three original stative verbs—*leave*, *remain* and *stay*—, we designed a version of the *implicit association test* (IAT) (Greenwald et al. 1998, 2015, Lane et al. 2007). The IAT aims at assessing the associative links between mental concepts and their attributes (Nosek et al. 2011, Uhlmann et al. 2012). It comprises a series of tasks that require participants to classify word stimuli into dichotomic categories, such as *positive* vs. *negative*. To measure the strength of associations, scholars rely on reaction times to stimuli that represent the concepts and attributes, which are presented in rapid succession. The underlying assumption of the IAT is that experiences can be represented by the facilitation of the information processing of associated concepts, as measured by the response time (Fazio & Olson 2003, Nosek et al. 2011). Thus, automatic attitudes are exhibited as influences on the duration of button-press responses, controlled by participants’ implicit evaluations.

For example, in the original version of the IAT, Greenwald et al. (1998) had participants classify nouns as referring typically to black vs. white Americans (the “target concepts”; e.g., “ebony” vs. “heather”) by left vs. right manual key presses, as well as different words as “pleasant” or “unpleasant” (the “attributes”). Concept and attribute classification were then combined, so that either “pleasant” or “unpleasant” were associated via classification mapping to “black” or “white”. Participants responded faster when mapping “white” to “pleasant” and “black” to “unpleasant” compared to the other mappings, which, according to the authors, suggests an underlying automatic associative structure that corresponds to certain stereotypes (in this example, racial stereotypes), and the IAT has been used numerous times since (for meta-analyses and reviews, see Hofmann et al. 2005, Lane et al. 2007, Greenwald et al. 2009).

The IAT is part of a larger family of so-called implicit measures, which have been developed to tap into reasons for individual perceptions, judgments, and behaviour (Greenwald et al. 2009, Nosek et al. 2011). Note that the IAT, unlike some other implicit measures, meets psychometric criteria including reliability and predictive validity (Hofmann et al. 2005, Greenwald et al. 2009, Fazio et al. 2003).

The following investigation attempted to illustrate, through a combination of linguistic as well as experimental analysis, that there are subliminal linguistic factors that can influence decision-making processes. These linguistic factors require more attention in the future.

Theoretical and linguistic background

Collective decision-making processes are an important topic in various scientific fields (Wooley et al. 2010, Jeanson et al. 2012, Robinson et al. 2014). In the present study, the question was

Referendum on the United Kingdom's membership of the European Union	
Vote only once by putting a cross <input checked="" type="checkbox"/> in the box next to your choice	
Should the United Kingdom remain a member of the European Union or leave the European Union?	
Remain a member of the European Union	<input type="checkbox"/>
Leave the European Union	<input type="checkbox"/>

Fig. 1 The ballot paper. The referendum ballot paper for voters in England, Scotland, and Northern Ireland (Electoral Commission 2016 p. 16).

whether it was a good choice to replace the neutral way of decision-making by means of a *yes/no* question with other, semantically more substantial linguistic means, such as an alternative choice between two verbs.

The 53 pages report (Electoral Commission 2015) and the assessment guidelines of the referendum questions elaborated by the electoral commission suggested an awareness of the relevance of linguistic factors in policy making. The first mention of *remain* dates back to October 2013 (section 2.5). In this context, the *yes/no* vote was also called into question (sections 2.7 and 5.18), although, this would represent a deviation from previous referendum questions. In the struggle to bypass a *yes/no* vote, *leave* appeared as a potential adversary to *remain*, but the Election Commission also admitted that it had not yet been able “to fully test the second of these two alternative question wordings in the time available [to them] before [they] reported” (section 2.8). Further tests followed in 2014, but section 3.9 (as well as 3.32 and 5.12) of the declaration expressly refers to the fact that “whilst qualitative research can identify participant reported views regarding neutrality of question wording based on participant perceptions, the approach does not capture any unconscious impact of question wording and structure. It is thus possible that questions might influence participants to answer in a particular way without them being aware of it”. Our study has been designed to shed light on this potentially important, yet under-explored impact of different verbal concepts as response options in political referendums.

For rational decision-making, it is necessary that decisions concerning the phrasing of a question and the linguistic material used for the encoding in a particular context are coherent (Fahlmann 1979, Arrow 1982, Brachmann & Schmolze 1985, Tversky & Kahneman 1986, Donini et al. 1996, Baader et al. 2004). Studies on rational decision-making have shown that framing effects do influence rational decisions (Dawes 1988, Levin et al. 1998, Stanovich & West 2000, 2008, Shafir & LeBoeuf 2002, Bruine de Bruin et al. 2007, West et al. 2008). In general, word and sentence meanings, which are mentally processed by each individual, undergo a subjective filtering mechanism (Lee 2001, Kövecses 2002, 2006, Croft & Cruse 2004, Van Gorp 2005, Evans & Green 2006, Langacker 1987, 2008, Evans 2009, Ruiz de Mendoza Ibáñez & Galera Masegosa 2014).

Moreover, the substantial influence that framing effects can have on readers has been demonstrated in several areas, such as psychology (Baumeister et al. 2001, Berry et al. 1997, Pennebaker et al. 2003), marketing (Anderson & Jolson 1980, Goh & Bockstedt 2013, Jensen et al. 2013), or news coverage (De Lange et al. 2012, Bosman et al. 2015). They play a major role in the cognitive sciences, artificial intelligence research (Minsky 1975), linguistics, and the communication sciences (Löbner 2015). Research on the reception of individual words has been conducted primarily in the field of sentiment analysis and polarity effect measurement. The focus in the different areas was on opinion building and mining (Neviarouskaya et al. 2009, Baccianella et al. 2010, Maks & Vossen 2012), big data analysis and information processing (Liebmann et al. 2012, Reschke & Anand 2011, Agarwal & Dhar 2014, Villarroel Ordenes et al. 2017), and risk perception and prediction (Arrow 1982, Oliveira et al. 2016). All these approaches have in common that they analyse the role of linguistic elements in decision-making processes (synchronic perspective) without focusing on the etymologically inherent framing effects (diachronic perspective).

The synchronic view considers language from a static perspective; it focuses on how language is used by its speakers at a given moment in time. The diachronic view, on the other hand, concentrates on the historic evolution of words, on how their meaning evolves (de Saussure 1967). Even though arbitrariness

has long been considered as one of the key features of the linguistic sign, a purely symbolic construal of language can only be entertained from a synchronic perspective. When examined diachronically, language seems far less random; instead, it appears to be directly connected to our perception and our experience (De Saussure 1989, Barsalou & Wiemer-Hastings 2005, Borghi & Cimatti 2009, Borghi & Bikofski 2014, Borghi & Caruana 2015).

Framing effects in particular originate at the interface of perception and linguistic coding. Due to the concept encoded in the linguistic root (cf. “parameters” below), an element can develop new functional areas. It is therefore particularly fascinating that while native speakers (as well as non-native speakers) usually have no access to etymology (diachrony), they have access to the conceptual parameters as the demarcation in the lexicon to other elements and thus the use of language (synchrony) is based on it (Weisgerber 1954/1973, Wierzbicka 1996, Varela 2005, Morera 2007, Lang & Maienborn 2011, Hernández Arocha 2014, Ströbel 2017).

Especially near-synonyms are an adequate tool to illustrate the strong connection between etymologically anchored parameters, which will be marked in the following with “[]”, and framing effects (Ströbel 2017). The adjectives *beautiful*, *good-looking*, *handsome*, *pretty*, *attractive*, *lovely*, and *stunning* can all function as synonyms in a given context, although – from a diachronic perspective – they refer to different parameters. *Beautiful* is derived from the Latin word *bellus*, *good-looking* refers to a [quality] and also implies a visual [evaluation], *handsome* has a “tactile” [contact] character and refers to the [shape] of something, *attractive* (< lat. *ad* ‘to’+ *trahere* ‘to draw’) to a [directed movement], *lovely* with its Proto-Indo-European root **leubh-* ‘to love’ to an [emotion], *stunning* (< lat. *tonāre* ‘to thunder’) to an [overwhelming force] and *pretty* originally referred to a scalar [value] or “a diminutive beauty, without the higher qualities of gracefulness” (Watson et al. 2013, Online Etymology Dictionary 2020). In the same way, *diligent*, *determined*, *industrious* and *enterprising* can, in a given context, due to semantic bleaching through frequency, be regarded as synonyms for *hardworking*, even though *diligent* (< lat. *legere* ‘to collect, read’, < PIE root **leǵ-* ‘to collect’ [action]) puts the focus rather on the acquisition process and therefore allows a shift from a physical (‘to collect’) to a mental (‘to read’) [effort], *determined* (< lat. *de* ‘down/off’ [direction] + *termināre* < PIE root **ter-* ‘(go to the) end’ [end point]) displays a telic, *industrious* (< lat. *in* ‘in’ + *struere* ‘to build’, < PIE root **ster-* ‘stiff’ [material]) a durative, *enterprising* (< lat. *inter* ‘among/in between’ *prehendere* ‘to take’ [directed action]) a causative character (Ströbel 2017).

In the present study, we were interested in whether response options such as *stay*, *remain*, and *leave*, which have been employed in the 1975 and 2016 UK referendums, might have activated different framing effects due to their underlying etymology.

The unique feature of our article is that it is the first time that the question of whether verbs are suitable as response options for political referendums in particular as well as decision-making processes in general has been addressed.

Regarding the formulation of the question itself and the use of verbs in the question, various studies already exist (Sudman & Bradburn 1982, Deutskens et al. 2004, Weisberg 2005, Friborg et al. 2006, Holleman 2006, Chessa & Holleman 2007, Swain et al. 2008, Saris et al. 2010, Kamoen & Holleman 2017). It has long been assumed that questions containing negation or negating verbs (cf. *not to allow/to forbid*) are more often answered with “no/disagree” than with “yes/agree” (Schuman & Presser 1981/1996, Kamoen et al. 2013, Warriner et al. 2013, Holleman et al. 2016). Moreover, that negative questions imply higher processing effort (Hoosain 1973, Sherman 1973, Clark 1976, Horn 1989, Kaup et al. 2006, Dillman et al. 2009).

However, these assumptions were put into perspective by the study of Kamoen et al. 2018. On the one hand, the conceptual interpretative framework must be considered (cf. *to allow* appears conceptually more complex and thus also more ambiguous than *to forbid*, cf. Holleman 2000), and on the other hand, the reference to the *status quo* seems to play a role. Similarly, the conceptually structuring role of interactions (cf. *stay*, *remain* vs. *leave*) is pointed out in Talmy's force dynamics (Talmy 1988). Force-interactive patterns imply strategies of identification and framing as well as positioning (Hart 2011), as a process is represented as a power interaction (cf. maintaining the *status quo* vs. changing the *status quo*) between actors (e.g. the voters, the EU). Kamoen et al. (2018) therefore suggest that a question on political issues should best be formulated in terms of a change from the *status quo*. For this reason, they also recommend that a country that is currently in the European Monetary Union should be asked whether it should leave the union rather than remain in it (Kamoen et al. 2018).

The findings underline, that verbs should be treated with caution, especially when it comes to decision-making, due to their complexity and the associated different association spectra; furthermore, the results display that especially the choice between static (*remain*) vs. dynamic (*leave*) in relation to the *status quo* can have an impact on voting behaviour.

Our article tackles therefore a very important question: If even small changes in the question can have large effects on the response (Schumann & Presser 1981, Cicourel 1982, Jobe & Mingay 1991, Molenaar & Smit 1996), what effects might cause the replacement of the *yes/no* response option by a heterogenic (static vs. dynamic) verbal alternative (*remain/leave*)?

The close connection between perception and linguistic encoding is a vital part of natural languages (Chao et al. 1999, Damasio et al. 1996, Vigliocco et al. 2014, 2011).

While *yes* etymologically refers to an intensified affirmation and *no* to an intense negation and thus both conceptually offer little room for interpretation, all three verbs (*stay*, *remain* and *leave*) show a conceptually higher complexity. Therefore, we assume that the differences we will find in the IATs (see our description earlier and in the section "Method") are due to implicit framing effects rooted in the etymology of the three verbs.

Remain can be traced back to the Latin verb *remanere* 'to be left behind (to die)', a derivation of the prefix *re-* 'back' and the verb *manere* 'to stay'; it implies the notion of being forced to stay in a [location] and suggests (in its most positive reading) maintaining the *status quo* (Levin 1993, Sorace 2000). This negative association is even more salient in the derived nominal form *remain*, as in 'human remains.'

In comparison, *stay* is derived from the Proto-Indo-European **sta-*, which is associated with a fixed [position]. *Stay* appears homogeneous from a diachronic as well as a synchronic point of view. In many languages, the continuation of the Latin verb *stare* can be found in auxiliary verbs (e.g., fr. *être* or sp. *estar*). Whereas the concept has thus functionally expanded, its semantics has not. The verb is therefore easily accessible and widely used in everyday language, which could even strengthen its positive interpretation. Furthermore, the combination /*st-*/ is usually associated with a force acting against gravity (cf. *STrength*, *STatics*, *STability*, etc.), ending a movement (cf. *STandstill*, *STop*, *STanding*, etc.), accompanying a movement (cf. *STamping*, *STepping*, *STinging*, *STorming*, etc.) or evoking an elongated object (cf. *STreet*, *STroke*, *STripe*, etc.) (Bolinger 1965, Philips 2000, 2012, Bottineau 2007, 2008, Ströbel 2018a, 2018b, 2019a, 2019b). The semantic stability of *stay*, combined with the sound-symbolic associations ("strength" and "straightness"), can even enhance the positive framing effects.

Leave is derived from the Old English causative *læfan* 'to allow sb. to stay in a [location] to survive', which can be traced back to the Proto-Indo-European root **leip-* 'stick, adhere' implying [contact]. The notion [contact] is further supported by the fact that, from a sound-symbolic perspective, /*l-*/ expresses connection as in *link*, *latch*, *lock* (Chomsky & Halle 1968, Rhodes & Lawler 1981). With time, *leave* turned into a dynamic achievement verb (Vendler 1967, Van Valin 1993, Van Valin & LaPolla 1997) and is nowadays associated with the dissolution of [contact] combined with an intended [change of location] (Gropen et al. 1991). Furthermore *leave* (/li:v/) shares phonological similarities with *believe* (/br'i:vi/, [+value]): *BeLEAVE* in the UK.

Taking this into account, while both verbs (*remain* and *leave*) originally refer to 'staying in a place', *remain* etymologically implies a negative ('dying') and *leave* a positive ('surviving') outcome ([value]) of the situation.

To briefly summarize and embed this linguistic and theoretical analysis before presenting two IAT studies: These three verbs etymologically refer to three stative and therefore durative associations, namely (a) *staying* in a fixed [position] with a strongly positive [value], (b) being left behind (to *remain*) in an unpleasant ([-value]) [location], and (c) not having to *leave* a safe [location] or heading to another one ([change of location], [+value]). In contrast to *stay* and *remain* (which maintained their stative reading ([position] or [location])), *leave*, over time, also developed dynamic and punctual readings implying a [change of location], e.g., *leave everything like it is* (stative) vs. *let's leave* (dynamic).

Language in general is assumed to have a clear semantic effect on thought: it can affect the way we conceptualize the world, and it can be associated with positive or negative experiences ([value(s)]) by virtue of its semantic embedding or its contextual reference (Sher & McKenzie 2006, 2008, Mandel 2008, 2014, Neviarouskaya et al. 2009, Reschke & Anand 2011, Maks & Vossen 2012, Chick et al. 2016).

Arguably, the framing effects emanating from these three verbs are even amplified by their association with bodily positions and sensorimotor movements (*staying* [position] or being stuck (*remaining*) in a [location] vs. *leaving* a [location]). Studies in the field from cognitive development to artificial intelligence show that different sensorimotor-based experiences shape the use and comprehension of complex situations and metaphorical statements (Nolfi & Floreano 2000, Oyama 2000, Beer 2003, Grossmann et al. 2008). The linguistic perspective is covered by theories in cognitive science that support the claim that many concepts are grounded in sensorimotor processes (Varela et al. 1991, Wilson 2002, Gibbs 2005, Barsalou 2008, Pezzulo 2011, Shapiro 2011, Wilson & Foglia 2011).

Processing such verbs probably re-activates memory records of previous episodes (O'Reagan & Noë 2001, Thompson & Varela 2001, Noë 2004, Spivey 2007, Goldman & de Vignemont 2009, Gallese 2010, De Jaegher et al. 2010, Núñez 2010, Thompson & Cosmelli 2011, Goldman 2012) that include sensorimotor-based experience, so that their evaluation is partly based on "embodied" representation of their meaning (Thompson 2007, Di Paolo 2009, Froese & Ziemke 2009, Jirak et al. 2010, Meteyard et al. 2012, Buccino et al. 2016). By just hearing or reading these verbs, our frame knowledge or our knowledge shaped by recurrent language action gets activated (Boulenger et al. 2008, Glenberg et al. 2008, Horoufchin et al. 2018).

Thus, even individual verbs never stand in isolation, but call up further framing effects that trigger each other (Gallese & Lakoff 2005, Casasanto & Lupyan 2015, Ströbel 2016). The present contribution will examine such potential framing effects of three isolated sensorimotor-based verbs. The novel approach consists in the notion that these apparently isolated verbs have a

representative function for a political decision with considerable consequences.

In the present study, we designed a version of an IAT in which we examined the idea that response times would be shorter when paired target categories (*remain vs. leave* or *stay vs. leave*) and attribute labels (positive vs. negative) match an individual’s automatic associations than when they do not match, that is, conversely, that response times would be longer when the paired target category and attribute labels contradict automatic associations (Greenwald et al. 2003). To this end, we conducted two IAT studies. In Study 1, we tested two groups of participants (i.e., *remain* combined with *leave* vs. combined with *stay*) in order to assess the relative evaluation of these terms with each group, and subsequently, we tested whether the difference in evaluation relative to *leave* changes as a function of the other verb (i.e., “stay” group vs. “remain” group). In Study 1, only a minority of the participants reported having English as native language. Study 2 was thus a replication study testing participants only in English-speaking countries.

Method

Stimulus material. We represented the sensorimotor concepts of *stay*, *leave*, and *remain* with the following terms: to represent the attribute categories of good vs. bad, we made use of word lists of previous IAT studies (e.g., Greenwald et al. 1998, Nosek et al. 2005, Hekman et al. 2010) and selected five positively and negatively connoted terms from these lists that are morphologically similar. We used the adjectives *good*, *outstanding*, *fantastic*, *wonderful*, and *excellent* as well as *bad*, *dreadful*, *nasty*, *terrible*, and *faulty*.

Procedure. We followed the general procedure of the seven-block IAT (Greenwald et al. 2015). As part of the task, participants had to press keys of a computer keyboard to assign stimuli that appeared on the screen to the left (using the key ‘e’ of a quartz keyboard) or the right (using the key ‘i’). Blocks 1 and 2 of the seven-block IAT were training blocks. In block 1, the target concepts (*remain vs. leave* or *stay vs. leave*, respectively) were presented on the upper left and right sides of the screen and participants assigned the appearing stimuli to these categories. Participants, then, trained with the attribute categories in block 2 by assigning the stimuli to the categories of *good vs. bad*. In block 3, the tasks from blocks 1 and 2 were combined. Now, participants had to assign stimuli of two categories to the left (e.g., *remain* and *good*) or to the right (e.g., *leave* and *bad*). Block 4 repeated this combination with an additional number of trials. The assignment of categories to the left and right trained in block 2 was reversed during block 5. Then, blocks 6 and 7 repeated the tasks from blocks 3 and 4 but with reversed combinations (e.g., *leave* and *good vs. remain* and *bad*).

Table 1 provides an overview of an exemplary order of categories for our IAT. In our experiment, we counterbalanced the combinations and their order of appearance across participants to control for potential condition order effects.

Per block, we presented the stimuli in random order on a light grey background in black letters. Stimuli were centred on the screen and remained there until the participants reacted. After each response, the next stimulus appeared after 400 ms. Except for block 4 and 7, all blocks of the seven-block IAT consisted of 20 trials and the two remaining blocks encompassed 40 trials. In sum, we recorded 180 reaction times per respondent.

All procedures performed in the present study were in accordance with the Helsinki declaration and comparable ethical standard. The study was not approved by an ethics committee because no physical or psychological discomfort and harm due to

Table 1 Illustrative structure of one IAT variant used in our experiment.

Block	Exemplary left key assignment	Exemplary right key assignment	Number of trials
1	Remain	Leave	20
2	Good	Bad	20
3	Remain	Leave	20
	Good	Bad	
4	Remain	Leave	40
	Good	Bad	
5	Leave	Remain	20
6	Leave	Remain	20
	Good	Bad	
7	Leave	Remain	40
	Good	Bad	

Table 2 The improved scoring algorithm developed by Greenwald et al. 2009.

Step	Task
1	Delete trials greater than 10,000 ms.
2	Delete samples for whom more than 10% of all trials have latency less than 300 ms.
3	Compute the pooled standard deviation for all trials in blocks 3 and 6 and accordingly for blocks 4 and 7.
4	Compute the mean of the correct latencies for each block.
5	Replace each error latency with block mean +600 ms.
6	Compute the mean of the resulting values for each block.
7	Compute two differences: Mean of block 6 minus mean of block 3 and accordingly for blocks 7 and 4.
8	Divide each difference score by its associated pooled standard deviation.
9	Compute the mean of the two resulting values.

the participation in this study was expected. Moreover, we did not use invasive methods and did not test underage persons or patients.

Measures. This study explored the polar evaluation of the concepts *stay vs. remain* relative to *leave* in two groups (*remain vs. leave* and *stay vs. leave*, respectively). As dependent measure, we constructed the so-called D-measure. The D-measure reflects the difference in reaction times of the experimental conditions of the within-subject design of the IAT. To compute it, we employed an algorithm developed by Greenwald, Nosek and Banaji 2003 to aggregate the 120 reaction times measured by the IAT during blocks 3 and 4 as well as 6 and 7. The algorithm accounts for extreme reactions times, i.e. too fast or slow responses, for classifications made incorrectly, and normalizes reactions time differences across experimental conditions of the task. Table 2 provides an overview of the algorithm underlying the D-measure.

As the D-measure is a relative measure, it can show negative as well as positive values. In our case, negative values indicate that the respective participant perceived *leave* as more positive and less negative than the respective other sensorimotor concept, i.e., *stay* or *remain*. In turn, positive values indicate that *leave* is associated less strongly with positive connotations but more strongly with negative ones when compared to *stay* or *remain*, respectively.

As part of our analysis, we first compared the implicit evaluation of *stay* and *remain* relative to *leave* (in two within-group comparisons). Secondly, we tested, across groups, the difference in evaluation of *stay vs. remain* relative to *leave* to

assess which comparison is more balanced in terms of evaluative structure.

Participants. We conducted two studies using this experimental setup. Study 1 (10/2019) used a convenience sampling strategy while we conducted Study 2 (5/2021) with English native speakers from different English-speaking countries. In both studies, participants were first informed about the purpose of the study (to study a linguistic question of the understanding of two verbs) using a few survey items as well as a reaction time test. Next, we communicated how data were stored, analysed, and utilized for scientific publication. We also informed participants about European data security laws and their right to withdraw their consent. Lastly, participants were notified of the fact that they would not receive any payment for taking part in the survey. Only participants agreeing to these conditions were then forwarded to the study. All subjects provided written consent. As this research explored the polar evaluation of the concepts *stay vs. remain* relative to *leave* in two experimental groups (*remain vs. leave* and *stay vs. leave*, respectively), participants were randomly assigned to one of the experimental groups in both studies.

For Study 1, we recruited participants by sharing the link to our online survey via our professional networks in various countries, emphasizing English-speaking regions. Of the 185 participants taking the test, 121 were female. On average, participants were 33.42 years old (std. dev. 14.63 years), with age ranging from 17 to 83 years. Although we focused on participants from English-speaking regions, only 46 of the participants indicated that their native language was English. Of the 185 participants, 92 took part in the condition of *remain vs. leave*, while 93 subjects worked on the IAT on *stay vs. leave*.

For Study 2, we contacted participants via the online service Click worker (approximate 1€ for a 4-to-6-minute task). Here, we sampled representative groups for the population of the UK and the USA. Of the 355 people that took our test, 181 stem from the UK. We surveyed 209 female, 141 male, and 5 diverse people. Age ranged from 18 to 70 years. Of the 355 participants, 182 took part in the condition of *remain vs. leave*, while 173 subjects worked on the IAT on *stay vs. leave*.

Results: study 1

We first report the results of each IAT independently for each experimental group. Since the average D-measure of the IAT using the combination *remain vs. leave* is positive ($\mu = 0.189$, $\sigma = 0.486$), the IAT reveals that participants on average perceived the word *remain* as slightly more positive and less negative than the word *leave*, $t(91) = 3.739$, $p < 0.001$, $r = 0.365$. The r-family effect size measure, based on Pearson's correlation r , indicates a medium sized effect. According to conventions suggested by Cohen (1988), $r < 0.1$ refers to a small effect, $r > 0.1$ & < 0.3 to a medium-sized effect, and $r > 0.5$ to a large effect size. Please note, however, that the D-measures have an interindividual range from -1.159 to 1.077 , depicting that at least few people also had an opposite association.

Similarly, the IAT investigating *stay vs. leave* showed that participants, on average ($\mu = 0.515$, $\sigma = 0.331$), considered the verb *stay* to be more positive and less negative than the verb *leave*, $t(92) = 12.979$, $p < 0.001$, $r = 0.804$, indicating a large effect size. Interestingly, the range of values that we observed (-0.327 ; 1.268) included fewer negative associations than in the other group.

After this analysis of the IATs and their D-measures, within each group, we compared both groups. The D-measures of the *stay vs. leave* IAT included more positive and higher values. A simple mean value comparison using an independent, two-sided (i.e., undirected) t -test showed a highly significant difference in

the D-measures between the groups *remain vs. leave* and *stay vs. leave*, $t(183) = -5.329$, $p < 0.001$, $r = 0.367$. This means that, in relation to the word *leave*, the word *remain* is connoted less positively and more negatively than the word *stay*. Statistically, this effect is of medium size.

Robustness checks. To inspect the robustness of our results, we replicated the above analyses for native English speakers only. We found qualitatively similar results regarding (1) the IAT using the combination *remain vs. leave* ($\mu = 0.264$, $\sigma = 0.527$), $t(25) = 2.551$, $p < 0.05$, $r = 0.454$; (2) the IAT testing the combination *stay vs. leave* ($\mu = 0.547$, $\sigma = 0.330$), $t(19) = 7.428$, $p < 0.001$, $r = 0.862$; and (3) the difference between the groups *remain vs. leave* and *stay vs. leave*, $t(44) = -2.097$, $p < 0.05$, $r = 0.301$. An additional ANOVA (Analysis of Variance) with the independent variables verb combination (*leave vs. stay*; *leave vs. remain*) and native language (English as native vs. non-native language) revealed that the D-measures differed across the IATs ($F(1,181) = 19.48$, $p < 0.001$, $\omega^2 = 0.092$) but not across native and non-native English speakers ($F(1,181) = 0.15$, $ns.$). Notably, the interaction of both variables was not significant, meaning that the differences across the IAT's did not differ between native and non-native English speakers ($F(1,181) = 0.20$, $ns.$).

Finally, we ran an OLS (Ordinary Least Squares) regression ($F(4,180) = 8.19$, $p < 0.001$, $\omega^2 = 0.154$) to control for potentially confounding effects of participants' age ($b = -0.003$, $ns.$), gender ($b = -0.051$, $ns.$), and also being native English speakers ($b = 0.125$, $ns.$). Again, we found support that the D-measures differed across group comparisons ($b = 0.319$, $p < 0.001$).

Results: study 2

In line with the reporting of our first study, we first report the results of each IAT. The average D-measure of the IAT in the combination *remain vs. leave* was positive ($\mu = 0.526$, $\sigma = 0.410$) indicating that participants on average perceived the word *remain* as slightly more positive and less negative than the word *leave*, $t(181) = 17.309$, $p < 0.001$, $r = 0.790$. The r-family effect size measure indicated a strong effect. As in Study 1, we found individual D-measures with an opposite association, as the range is from -0.908 to 1.373 . People from the UK ($\mu = 0.504$, $\sigma = 0.415$) and the USA ($\mu = 0.547$, $\sigma = 0.406$) did not differ in D-measures, $t(180) = -0.7114$, $ns.$

Participants in the IAT *stay vs. leave* also exhibited on average a positive D-measure ($\mu = 0.592$, $\sigma = 0.351$). As such, participants perceived the verb *stay* to be more positive and less negative than the verb *leave*, $t(172) = 22.213$, $p < 0.001$, $r = 0.861$. The effect size measures indicated a strong effect. As in Study 1, the range of values included fewer negative associations (-0.391 ; 1.319) compared to the combination of *remain vs. leave*. Again, people from the UK ($\mu = 0.562$, $\sigma = 0.367$) and the USA ($\mu = 0.622$, $\sigma = 0.333$) did not differ in the D-measures, $t(171) = -1.134$, $ns.$

Our final set of analyses compared the IATs across the two groups tested in Study 2. We found, similarly to Study 1, that in comparison to the word *leave*, the word *remain* ($\mu = 0.526$, $\sigma = 0.410$) was connoted less positively and more negatively than the word *stay* ($\mu = 0.592$, $\sigma = 0.351$). Compared to Study 1, however, we found only a smaller group difference of the D-measures between the two IATs, $t(353) = -1.619$, $p < 0.53$, $r = 0.086$ (two-tailed). Note, however, given that Study 1 informed a directed prediction, we believe that a one-tailed t -test would be justifiable, in which case the result would be considered statistically significant (i.e., $p < 0.027$). Hence, we take the results of Study 2 as a confirmation of the pattern observed in Study 1.

Discussion

Using a version of the IAT, we tested the suitability of two near synonyms (*stay* and *remain*) in combination with a potential antonym (*leave*) as an alternative response option in decision-making processes. The important findings were that *remain* was found to be connoted less positively and more negatively than its near synonym *stay* when evaluated in relation to *leave*. However, *remain* was evaluated still more positively than *leave* (Study 1). In addition, we found a substantial increase in negative perceptions of *leave* between Study 1 and Study 2. Notably, there were no significant differences in the empirical effects (the D-measure) between English native speakers (L1) and non-native speakers (L2) in Study 1 and people from the UK and the USA (L1) in Study 2. Furthermore, age groups and gender did not reliably affect the observed data.

How can it be that near-synonyms (*stay* vs. *remain*) display such salient differences in their evaluative structures, and why do framing effects appear to be affected neither by language nor by age or gender? And finally, what could explain the dynamics in the perception of *leave*? We will discuss these questions in turn.

We assume that the reasons for the fact that the participants perceived the verb *stay* to be more positive and less negative than its potential synonym *remain*, as well as its antonym *leave*, are due to implicit framing effects rooted in the etymology of *stay*.

As already mentioned in the “Theoretical and Linguistic Background” section, even though speakers may not have any direct access to etymology at all, the conceptual parameters that determine the functional range of an element in a given language are similarly accessible to L1 and L2 speakers. Therefore, *stay*, besides its etymological association with a fixed [position], displays from a phonetic-symbolic perspective prototypical readings associated with (a) a [force] acting against gravity (cf. *STrength*, *STability*, etc.), ending a movement (cf. *STandstill*, *STop*, etc.) or accompanying a movement (cf. *STamping*, *STorming*, etc.), as well as, (b) a specific [shape] (cf. *STreet*, *STroke*, etc.). The sound-symbolic associations of *stay*, implying “strength” and “straightness”, as well as the etymological associations suggesting “stability” and “security”, have the power to activate positive framing effects. *Remain*, on the contrary, displays the negative notion of being forced to stay in a [location] as it can be traced back to the Latin verb *remanere* ‘to be left behind (to die)’. Similarly, *leave* (derived from the Old English causative *læfan* ‘to allow sb. to stay in a [location] to survive’) is associated with an unpleasant situation, in which originally the survival of someone was ensured by leaving them behind.

Taking this into account, both verbs, *remain* and *leave*, originally refer to ‘staying in a place’, but etymologically *remain* implies a negative (‘dying’ [-value]) and *leave* a positive (‘surviving’ [+value]) outcome of the situation. Nevertheless, the difference between *remain* vs. *leave* was not as salient as expected in the IAT (cf. Study 1, but even less in Study 2). We assume that a suppressive effect in Study 1 caused by the fact that the combination *remain* vs. *leave* (other than *remain* vs. *stay*) was closely linked to the Brexit debate and that the majority of participants of Study 1 had an academic background and might have therefore been more likely to associate *leave* with something negative, which has more than levelled the etymologically positive [value] (Moore 2016). Nevertheless, in Study 2, people with different backgrounds from the UK ($\mu = 0.504$, $\sigma = 0.415$) and the USA ($\mu = 0.547$, $\sigma = 0.406$) did not differ in D-measure ($t(180) = -0.7114$, *ns*), which makes it unlikely for the level of support for membership in the European Union to dilute the linguistic effect that we seek to isolate. Furthermore, the deviations encountered in Study 2, which was conducted with a considerable time lag to Study 1, could also be explained by the fact, that it cannot be ruled out that in the meantime, due to awareness of the social and economic consequences of Brexit, the evaluation or perception of these three verbs might have fluctuated or changed.

In other words, a suppressive effect linked to the synchronic or actual connotations of *remain* vs. *leave* might have levelled out the diachronic or etymological associations of *remain*, and even more of *leave*. This is supported by the finding that the r-family effect size measure only indicates a medium-sized effect and that the d-measures (ranging from -1.159 to 1.077) are depicting that at least few people also had an opposite association.

As mentioned before, our study is not concerned with the justification of potential choice of pairs of response options; it rather aimed at contributing to a discussion as to whether verbs in general should be used as response options due to inherent framing effects and therefore their lack of neutrality. In this context it is notable that in Study 1, we could not find significant differences in the IAT between L1 and L2 speakers, nor could we detect differences in Study 1, as well as in Study 2, between different age groups or genders.

This might be due to the fact that all three verbs are sensorimotor-based concepts. As indicated previously, bodily concepts are experienced by humans in a particularly intense manner and sensorimotor-based verbs are more likely to be remembered than others. We assume, therefore, that when we hear verbs, such as *stay*, *remain*, or *leave*, some kind of “embodied” processing mechanism referring to the neural systems responsible for balancing the body in that particular [position] or carrying out the respective [movement] is implicitly activated, to some degree. This kind of mental simulation or mental “re-enactment” generates a stronger identification with what is said, since the perception is ‘experienced’ not only audibly or visually, but also at the sensorimotor level, and this experience is language, independently of age and gender.

Sensorimotor-based concepts can be found in many areas of language, like, for instance, in *to comprehend* (<lat. *comprehendere* ‘to catch hold of, seize’ [contact]) or *to grasp* (an idea). Both verbs imply that in order to understand something, one must first examine it with the sense of touch [contact]. In grammar, too, sensorimotor concepts are often used to verbalize complex facts, as when movement in space is used to express movement in time (cf. *I am going to do sth.* [change of location]). The strong anchoring of these concepts in the mental lexicon as well as in grammatical structures may explain why we could not find significant differences in the IAT between L1 and L2 speakers, age groups or gender.

Framing effects in isolated linguistic units are based on the interaction of perception, cognition, and language. The underlying processes are rarely actively accessible even to L1 speakers. Nevertheless, the underlying universal structures or basic parameters (such as [location], [position], [contact], [change of location], etc.) seem to have an influence, at least unconsciously, on the concrete contexts of use. This obvious paradox between a lack of transparency on the one hand and intuitively coupled connotations with the coding parameters on the other hand is also evident in the IAT.

It should be noted that the IAT has been criticized on methodological grounds, for example, because it provides only a relative rather than an absolute measure of evaluative structure. Moreover, the resulting D-measure may not be sufficiently reliable in order to allow strong diagnostic predictions at the level of the individual, especially because the link between implicit measure of evaluative structure to actual behaviour may not be very strong in certain applied contexts (cf. e.g., Antons et al. 2017 for discussion). Yet, for the present purposes, we were interested in relative rather than in absolute effects on evaluative structure and given the statistical power of general elections (with millions of voting participants), statistically small effects on evaluative structure, even if reflecting only weak relations to overt behaviour, could still have a significant and meaningful impact on explicit voting behaviour.

Taking this into account, verbs in general and sensorimotor verbs in particular have the inherent power, due to their framing effects,

to convey a great deal of information in a concise manner, and to condense complex issues into more simplified packages of information by defining patterns of perception (via embodiment and enaction processes) to which people can respond. In other words, verbs are suitable in many contexts (marketing, campaigning, etc.) as they help to address symbolic themes residing in segments of public awareness. Nevertheless, as suggested by our data, they might be, due to their strong language-, gender-, and age-independent framing effects, less suitable as alternative response options.

Therefore, it might be wise to limit the use of such verbs to the formulation of questions, rather than use them as linguistic anchors for the behavioural choice decision itself. This could contribute to voting behaviour less prone to bias and to a more objective formulation of referendum questions.

In order to be able to show even more clearly the greater scope for interpretation and the stronger context-dependency of verbal response options in comparison to the conceptually simpler, context-independent and already established *yes/no* alternative, we can envisage further studies analysing non-sensorimotor based concepts, simple vs. complex predicates (cf. *hold/keep* vs. *give away/let go*), the role of negation (*do* vs. *do not*) or verbs sharing the same etymology but differing in their scalar orientation (cf. *decrease* vs. *increase*).

Conclusion

As many studies have shown that small changes in the formulation of a question can have large effects on the decision, our article addressed the question of whether two heterogenic (static vs. dynamic) verbs can function as response alternatives in an important decision-making process. We used the two referendums on membership of the European Union in the United Kingdom in 1975 and 2016 as a case study, as the *yes/no* response option was replaced in the second referendum (2016), in contrast to 1975, by a verbal and conceptually more complex alternative response option (*remain/leave*). Our aim was therefore to illustrate that verbal framing effects can influence decision-making processes through a combined linguistic and experimental analysis. Overall, the data from two temporally separated IATs, focussing on L2 (Study 1, $n = 185$) and L1 speakers (Study 2, $n = 355$), suggests that the exact wording of dichotomous response options has the potential to influence response choice. As a result, verbs seem therefore less suitable to replace *yes/no* response options.

Data availability

All relevant data are within the manuscript. We cannot provide further access to the data of this study, as the data was collected under the data privacy act of the European Union. Therefore, we had to inform participants about data usage and storage. The participants have consented to the study with the assurance that the data will only be stored locally and only evaluated for this study and will not be passed on to third parties.

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References

Agarwal R, Dhar V (2014) Big data, data science, and analytics: The opportunity and challenge for IS research. *Inf Syst Res* 25(3):443–448. <https://doi.org/10.1287/isre.2014.0546>

Anderson RE, Jolson MA (1980) Technical wording in advertising: implications for market segmentation. *J Market* 44(1):57–66. <https://doi.org/10.1177/002224298004400108>

Antons D, Declerck M, Diener K, Koch I, Piller F (2017) Assessing the Not-Invented-Here Syndrome: Development and validation of implicit and explicit measurements. *J Organ Behav* 38:1227–1245. <https://doi.org/10.1002/job.2199>

Arrow KJ (1982) Risk perception in psychology and economics. *Econ Inquiry* 20:1–9. <https://doi.org/10.1111/j.1465-7295.1982.tb01138.x>

Baader F, Calvanese D, McGuinness DL, Nardi D, Patel-Schneider PF (2004) *The Description Logic Handbook: Theory, Implementation, and Applications*. Cambridge University Press, New York, (eds)

Baccianella S, Esuli A, Sebastiani F (2010) SentiWordNet 3.0: An enhanced lexical resource for sentiment analysis and opinion mining. In: *Proceedings of the Seventh International Conference on Language Resources and Evaluation (LREC'10)*. Istituto di Scienza e Tecnologie dell'Informazione, Consiglio Nazionale delle Ricerche, Pisa, p 2200–2204

Barsalou LW (2008) Grounded cognition. *Annu Rev Psychol* 59:617–645. <https://doi.org/10.1146/annurev.psych.59.103006.093639>

Barsalou LW, Wiemer-Hastings K (2005) Situating abstract concepts. In: Pecher D, Zwaan R, (eds) *Grounding cognition: The role of perception and action in memory, language, and thought*. Cambridge University Press, Cambridge (UK), p 129–163

Baumeister RF, Bratslavsky E, Finkenauer C, Vohs KD (2001) Bad is stronger than good. *Rev Gen Psychol* 5(4):323–370. <https://doi.org/10.1037/1089-2680.5.4.323>

Beer R (2003) The dynamics of active categorical perception in an evolved model agent. *Adapt Behav* 11:209–243

Berry DS, Pennebaker JW, Mueller JS, Hiller WS (1997) Linguistic bases of social perception. *Personality and Social Psychology Bulletin* 23(5):526–537. <https://doi.org/10.1177/0146167297235008>

Bolinger, DLM (1965) Rime, Assonance and Morpheme Analysis. In: Bolinger DLM (ed) *Forms of English: Accent, Morpheme, Order*. Harvard University Press, Cambridge, Massachusetts, p 203–209

Borghi A, Caruana F (2015) Embodiment theories. In: Wright JD (ed) *International Encyclopedia of the Social & Behavioral Sciences* 7. Elsevier, Oxford, p 420–426

Borghi, AM, Binkofski F (2014) *Words as social tools: An embodied view on abstract concepts*. Springer, New York

Borghi, AM, Cimatti F (2009) Words as tools and the problem of abstract words meanings. In: Taatgen N, van Rijn H (eds) (2009) *Proceedings of the 31st Annual Conference of the Cognitive Science Society*. Cognitive Science Society, Austin (TX), p 2304–2309

Bosman R, Kräussl R, Mirgorodskaya E (2015) The “tone effect” of news on investor beliefs: An experimental approach. *CFS Working Paper Series* 522:1–76

Bottineau D (2008) The submorphemic conjecture in English: Towards a distributed model of the cognitive dynamics of submorphemes. *Lexis, Journal in English Lexicology* 2:19–42

Bottineau D (2007) Language and enaction. In: Stewart J, Gapenne O, Di Paolo E (eds) *Enaction: towards a new paradigm for cognitive science*. MIT Press, Cambridge MA, p 267–306

Boulenger V, Hauk O, Pulvermüller F (2008) Grasping ideas with the motor system: semantic somatotopy in idiom comprehension. *Cereb Cortex* 19(8):1905–1914

Brachman R, Schmolze JG (1985) An overview of the KL-ONE knowledge representation system. *Cogn Sci* 9(2):171–216

Bruine de Bruin W, Parker AM, Fischhoff B (2007) Individual differences in adult decision-making competence. *J Pers Soc Psychol* 92:938–956. <https://doi.org/10.1037/0022-3514.92.5.938>

Buccino G, Colagè I, Gobbi N, Bonaccorso G (2016) Grounding meaning in experience: A broad perspective on embodied language. *Neurosci Biobehav Rev* 69:69–78

Casasanto D, Lupyan G (2015) All concepts are Ad Hoc Concepts. In: Margolis E, Laurence S (eds) *The Conceptual Mind: New directions in the study of concepts*. MIT Press, Cambridge (MA), p 543–566

Chao LL, Haxby JV, Martin A (1999) Attribute-based neural substrates in temporal cortex for perceiving and knowing about objects. *Nat Neurosci* 2(10):913–919. <https://doi.org/10.1038/13217>

Chessa AG, Holleman BC (2007) Answering attitudinal questions: modelling the response process underlying contrastive questions. *Applied Cognitive Psychology* 21(2):203–225. <https://doi.org/10.1002/acp.1337>

Chick CF, Reyna VF, Corbin J (2016) Framing effects are robust to linguistic disambiguation: A critical test of contemporary theory. *J Exp Psychol Learn Mem Cogn* 42(2):238–256

Chomsky N, Halle M (1968) *The Sound Pattern of English*. Harper & Row, New York

Cicourel AV (1982) Interviews, Surveys, and the Problem of Ecological Validity. *The American Sociologist* 17(1):11–20. <http://www.jstor.org/stable/27702491>

Clark HH (1976) *Semantics and comprehension*. Mouton, The Hague

Cohen J (1988) *Statistical Power Analysis for the Behavioral Sciences*. Routledge, London

- Croft W, Cruse DA (2004) *Cognitive Linguistics*. Cambridge Textbooks in Linguistics. Cambridge University Press, Cambridge & New York <https://doi.org/10.1017/CBO9780511803864.009>
- Damasio H, Grabowski TJ, Tranel D, Hichwa RD, Damasio AR (1996) A neural basis for lexical retrieval. *Nature* 380(6574):499. <https://doi.org/10.1038/380499a0>
- Dawes RM (1988) *Rational choice in an uncertain world*. Harcourt Brace Jovanovich College Publishers, San Diego (CA)
- De Jaegher H, Di Paolo E, Gallagher S (2010) Can Social Interaction Constitute Social Cognition? *Trends in Cognitive Sciences* 14(10):441–447. <https://doi.org/10.1016/j.tics.2010.06.009>
- De Lange R, Schuman H, Montessori (2012) *Kritische discoursanalyse: de macht en kracht van taal en tekst*. Academic & Scientific Publishers, Brussels
- Deutschens E, De Ruyter K, Wetzels M, Oosterveld P (2004) Response rate and response quality of Internet-based surveys: an experimental study. *Marketing Letters* 15(1):21–36
- De Saussure, F (1989) *Cours de linguistique générale*. Otto Harrassowitz, Wiesbaden
- De Saussure F (1967) *Grundfragen der allgemeinen Sprachwissenschaft*. De Gruyter, Berlin
- Dillman D, Smith JD, Christian JM (2009) *Internet, mail, and mixed mode surveys: the tailored design method*. Wiley, Hoboken, NJ
- Di Paolo E (2009) *Extended Life*. *Topoi* 28:9–21
- Donini FM, Lenzerini M, Nardi D, Schaerf A (1996) Reasoning in description logics. *Principles of knowledge representation* 1:191–236
- Electoral Commission (2015) *Referendum on membership of the European Union. Assessment of the Electoral Commission on the proposed referendum question*. <https://www.electoralcommission.org.uk/sites/default/files/2019-08/EU-referendum-question-assessment-report.pdf>
- Electoral Commission (2016) *Report on the 23 June 2016 referendum on the UK's membership of the European Union*. https://www.electoralcommission.org.uk/sites/default/files/pdf_file/2016-EU-referendum-report.pdf
- Evans V (2009) *How Words Mean*. Oxford University Press, Oxford
- Evans V, Green M (2006) *Cognitive linguistics: An introduction*. Edinburgh University Press, Edinburgh
- Fahlmann SE (1979) *A System for Representing and Using Real-world Knowledge*. The MIT Press, Cambridge, (MA)
- Fazio RH, Olson MA (2003) Implicit measures in social cognition research: Their meaning and use. *Annu Rev Psychol* 54(1):297–327
- Friborg O, Martinussen M, Rosenvinge JH (2006) Likert-based versus semantic differential-based scorings of positive psychological constructs: a psychometric comparison of two versions of a scale measuring resilience. *Personality and Individual Differences* 40(5):873–884. <https://doi.org/10.1016/j.paid.2005.08.015>
- Froese T, Ziemke T (2009) *Enactive Artificial Intelligence: Investigating the Systemic Organization of Life and Mind*. *Artif Intell* 173(3-4):466–500
- Gallese V (2010) Embodied Simulation and Its Role in Intersubjectivity. In: Fuchs T, Sattel HC and Henningsen P (eds) *The Embodied Self. Dimensions, Coherence and Disorders*. Schattauer, Stuttgart, p 78–92
- Gallese V, Lakoff G (2005) The brain's concepts: The role of the sensory-motor system in conceptual knowledge. *Cogn Neuropsychol* 22(3-4):455–479. <https://doi.org/10.1080/02643290442000310>
- Gibbs RW (2005) *Embodiment and Cognitive Science*. Cambridge University Press, New York
- Glenberg AM, Sato M, Cattaneo L, Riggio L, Palumbo D, Buccino G (2008) Processing abstract language modulates motor system activity. *Q J Exp Psychol* 61(6):905–919
- Goh KH, Bockstedt JC (2013) The framing effects of multipart pricing on consumer purchasing behavior of customized information good bundles. *Inf Syst Res* 24(2):334–351
- Goldman A (2012) A Moderate Approach to Embodied Cognitive Science. *Rev Philos Psychol* 3(1):71–88
- Goldman A, de Vignemont F (2009) Is Social Cognition Embodied? *Trends Cogn Sci* 13(4):154–159
- Greenwald AG, Banaji MR, Nosek BA (2015) Statistically small effects of the Implicit Association Test can have societally large effects. *J Pers Soc Psychol* 108(4):553–561. <https://doi.org/10.1037/pspa0000016>
- Greenwald AG, Poehlman TA, Uhlmann EL, Banaji MR (2009) Understanding and using the implicit association test: III. Meta-analysis of predictive validity. *J Pers Soc Psychol* 97(1):17–41
- Greenwald AG, Nosek BA, Banaji MR (2003) Understanding and using the implicit association test: I. An improved scoring algorithm. *J Pers Soc Psychol* 85(2):197–216. <https://doi.org/10.1037/0022-3514.85.2.197>
- Greenwald AG, McGhee DE, Schwartz JL (1998) Measuring individual differences in implicit cognition: the implicit association test. *J Pers Soc Psychol* 74(6):1464–1480
- Gropen J, Pinker S, Hollander M, Goldberg R (1991) Affectedness and direct objects: The role of lexical semantics in the acquisition of verb argument structure. *Cognition* 41(1-3):153–195. [https://doi.org/10.1016/0010-0277\(91\)90035-3](https://doi.org/10.1016/0010-0277(91)90035-3)
- Grossman M, Anderson C, Khan A, Avants B, Elman L, McCluskey L (2008) Impaired action knowledge in amyotrophic lateral sclerosis. *Neurology* 71(18):1396–1401
- Hart C (2011) Force-Interactive Patterns in Immigration Discourse: A Cognitive Linguistic Approach to CDA. *Discourse & Society* 22(3):269–286
- Heckman J, Seong HM, Pinto R, Savelyev P, Yavitz A (2010) Analyzing Social Experiments as Implemented: A Reexamination of the Evidence from the High Scope Perry Preschool Program. *Quant Econom* 1:1–46
- Hernández Arocha H (2014) *Las familias de Palabras, Relaciones entre morfología, semántica y estructura argumental en las raíces “dec(ir)” y “sag(en)”*. Beihefte zur Zeitschrift für Romanische Philologie, Edition Niemeyer, De Gruyter, Berlin
- Hofmann W, Gawronski B, Gschwendner T, Le H, Schmitt M (2005) A meta-analysis on the correlation between the implicit association test and explicit self-report measures. *J Pers Soc Psychol* 31(10):1369–1385
- Holleman BC (2000) The forbid/allow asymmetry. On the cognitive mechanisms underlying wording effects in surveys. *Rodopi, Amsterdam*
- Holleman BC (2006) The meanings of ‘yes’ and ‘no’. An explanation for the forbid/allow asymmetry. *Quality and Quantity* 40(1):10–38. <https://doi.org/10.1007/s11355-005-4479-6>
- Holleman BC, Kamoen N, Krouwel A, Van de Pol J, De Vreese CH (2016) Positive vs. negative: the impact of question polarity in voting advice applications. *Plos One* 11(10). <https://doi.org/10.1371/journal.pone.0164184>
- Hoosain R (1973) The processing of negation. *Journal of Verbal Learning and Verbal Behaviour* 12(6):618–626
- Horn LR (1989) *A natural history of negation*. Chicago University Press, Chicago
- Horoufchin H, Bzdok D, Buccino G, Borghi AM, Binkofski F (2018) Action and object words are differentially anchored in the sensory motor system-A perspective on cognitive embodiment. *Scientific reports* 8(1):6583
- Jeanson R, Dussoutour A, Fourcassié V (2012) Key factors for the emergence of collective decision in invertebrates. *Front. Neurosci* 6:121
- Jensen ML, Averbach JM, Zhang Z, Wright KB (2013) Credibility of anonymous online product reviews: A language expectancy perspective. *J Manag Inf Syst* 30(1):293–324. <https://doi.org/10.2753/MIS0742-1222300109>
- Jirak D, Menz MM, Buccino G, Borghi AM, Binkofski F (2010) Grasping language—a short story on embodiment. *Conscious Cogn* 19(3):711–720. <https://doi.org/10.1016/j.concog.2010.06.020>
- Jobe JB, Mingay DJ (1991) *Cognition and Survey Measurement: History and Overview*. *Applied Cognitive Psychology* 5:175–192
- Kamoen N, Holleman BC (2017) I don't get it. Response difficulties in answering political attitude statements in voting advice applications. *Survey Research Methods* 11(2):125–140. <https://doi.org/10.18148/srm/2017.v11i2.6728>
- Kamoen N, van de Pol J, Krouwel APM, de Vreese C, Holleman B (2018) I don't know. The effect of question polarity on no-opinion answers. Web publication or Website, American Association for Public Opinion Research. <http://www.surveypactice.org/article/3222-i-don-t-know-the-effect-of-question-polarity-on-no-opinion-answers>
- Kamoen N, Holleman BC, Van den Bergh H (2013) Positive, negative, and bipolar questions: the effect of question polarity on ratings of text readability. *Survey Research Methods* 7(3):181–189
- Kaup B, Ludtke J, Zwaan RA (2006) Processing negated sentences with contradictory predicates: is a door that is not open mentally closed? *Journal of Pragmatics* 38(7):1033–1050. <https://doi.org/10.1016/j.pragma.2005.09.012>
- Kövecses Z (2002) *Emotion concepts: Social constructionism and cognitive linguistics*. In: Fussell SR (ed) *The verbal communication of emotions*. Lawrence Erlbaum Associates, Mahwah (NJ), p 117–132
- Kövecses Z (2006) *Language, Mind, and Culture: A Practical Introduction*. Oxford University Press, Oxford
- Lane KA, Banaji MR, Nosek BA, Greenwald AG (2007) Understanding and using the implicit association test: IV. In: Wittenbrink B, Schwarz N (eds) *Implicit measures of attitudes*. The Guilford Press, New York, p 59–102
- Lang E, Maienborn C (2011) Two-level Semantics: Semantic Form and Conceptual Structure. In: Maienborn C, von Stechow K, Portner P (eds), *Semantics: An International Handbook of Natural Language Meaning*, vol. I, de Gruyter, Berlin/Boston
- Langacker RW (2008) *Cognitive Grammar. A basic introduction*. Oxford University Press, Oxford
- Langacker RW (1987) *Foundations of cognitive grammar*. Stanford University Press, Stanford
- Lee D (2001) *Cognitive Linguistics: An Introduction*. Oxford University Press, Oxford
- Levin B (1993) *English verb classes and alternations: A preliminary investigation*. The University of Chicago Press, Chicago
- Levin IP, Schneider SL, Gaeth GJ (1998) All frames are not created equal: A typology and critical analysis of framing effects. *Organ Behav Hum Decis Process* 76(2):149–188. <https://doi.org/10.1006/obhd.1998.2804>

- Liebmann M, Hagenau M, Neumann D (2012) Information processing in electronic markets: Measuring subjective interpretation using sentiment analysis. In: Proceedings of the International Conference on Information Systems. Association for Information Systems, p 683-700
- Löbner S (2015) Functional Concepts and Frames. In: Gamerschlag T, Gerland D, Osswald R, Petersen W (eds) *Meaning, Frames, and Conceptual Representation, Studies in Language and Cognition 2*. Düsseldorf University Press, Düsseldorf, p 13-42
- Maks I, Vossen P (2012) A lexicon model for deep sentiment analysis and opinion mining applications. *Decis Support Syst* 53(4):680-688
- Mandel DR (2014) Do framing effects reveal irrational choice? *J Exp Psychol Gen* 143(3):1185-1198. <https://doi.org/10.1037/a0034207>
- Mandel DR (2008) Violations of coherence in subjective probability: A representational and assessment processes account. *Cognition* 106:130-156. <https://doi.org/10.1016/j.cognition.2007.01.001>
- Meteyard L, Cuadrado SR, Bahrami B, Vigliocco G (2012) Coming of age: A review of embodiment and the neuroscience of semantics. *Cortex* 48(7):788-804. <https://doi.org/10.1016/j.cortex.2010.11.002>
- Minsky M (1975) A framework for representing knowledge. In: Winston P (ed) *The Psychology of Computer Vision*. McGraw-Hill, New York, p 211-277
- Molenaar NJ, Smit JH (1996) Asking and answering yes/no-questions in survey interviews: a conversational approach. *Qual Quant* 30:115-136. <https://doi.org/10.1007/BF00153983>
- Morera M (2007) Los cambios semánticos de las raíces léxicas. In: Emsel M, Cuartero Otal J (eds), *Brücken, Übersetzen und interkulturelle Kommunikation. Festschrift für Gerd Wotjak zum 65. Geburtstag*, vol. 2, Peter Lang, Frankfurt am Main
- Moore P (2016) How Britain voted at the EU referendum. <https://yougov.co.uk/topics/politics/articles-reports/2016/06/27/how-britain-voted>
- Neviarouskaya A, Prendinger H, Ishizuka M, Sentifil (2009) Generating a reliable lexicon for sentiment analysis. In: 3rd International Conference on Affective Computing and Intelligent Interaction and Workshops. IEEE p 1-6
- Noë A (2004) *Action in Perception*. MIT Press, Cambridge (MA)
- Nolfi S, Floreano D (2000) *Evolutionary Robotics: The Biology, Intelligence, and Technology of Self-Organizing Machines*. MIT Press, Cambridge (MA)
- Nosek BA, Hawkins CB, Frazier RS (2011) Implicit social cognition: From measures to mechanisms. *Trends Cogn Sci* 15(4):152-159
- Nosek BA, Greenwald AG, Banaji MR (2005) Understanding and using the Implicit Association Test: II. Method variables and construct validity. *J Pers Soc Psychol* 31(2):166-180
- Núñez R (2010) Enacting Infinity: Bringing Transfinite Cardinals into Being. In: Stewart J, Gappene O, Di Paolo E (eds) *Enaction: Towards a New Paradigm in Cognitive Science*. MIT Press, Cambridge (MA), p 307-333
- O'Regan KJ, Noë A (2001) A sensorimotor account of vision and visual consciousness. *Behav Brain Sci* 24(5):883-917
- Oliveira N, Cortez P, Areal N (2016) The impact of microblogging data for stock market prediction: Using Twitter to predict returns, volatility, trading volume and survey sentiment indices. *Expert Syst Appl* 73:125-144. <https://doi.org/10.1016/j.dss.2016.02.013>
- Online Etymology Dictionary (2020). <https://www.etymonline.com/word/pretty>
- Oyama S (2000) *The ontogeny of information: Developmental systems and evolution* (Second edition). Duke University Press, North Carolina
- Pennebaker JW, Mehl MR, Niederhoffer KG (2003) Psychological aspects of natural language use: Our words, our selves. *Annu Rev Psychol* 54(1):547-577
- Pezzulo G (2011) Grounding Procedural and Declarative Knowledge in Sensorimotor Anticipation. *Mind Lang* 26(1):78-114
- Philps D (2012) Submorphemes: backtracking from English 'kn-words' to the emergence of the linguistic sign. *Miranda. Revue pluridisciplinaire du monde anglophone* 7. <https://doi.org/10.4000/miranda.4244>
- Philps D (2000) Le sens retrouvé ? : de la nomination de certaines parties du corps : le témoignage des marqueurs sub-lexicaux et l'anglais en "CN-". *Anglophonia: french journal of english studies* 8:207-232
- Reschke K, Anand P (2011) Extracting contextual evaluativity. In: Proceedings of the Ninth International Conference on Computational Semantics. Association for Computational Linguistics, p 370-374
- Rhodes R, Lawler J (1981) *Athematic Metaphors*. In: Hendrik R, Masek C, Miller MF (eds) *Papers from the 17th Regional Meeting*. Chicago Linguistic Society, Chicago, p 318-342
- Robinson EJH, Feinerman O, Franks NR (2014) How collective comparisons emerge without individual comparisons of the options. *Proc. R. Soc. B Biol. Sci* 281:1787
- Ruiz de Mendoza Ibáñez FJ, Galera Masegosa A (2014) *Cognitive Modeling. A linguistic perspective*. John Benjamins, Amsterdam
- Saris W, Revilla M, Krosnick JA, Shaeffer EM (2010) Comparing questions with agree/disagree response options to questions with construct-specific response options. *Surv Res Methods* 4(1):61-79
- Schuman H, Presser S (1981/1996) *Questions and answers in attitude surveys. experiments on form, wording and context*. Academic Press, London, England
- Shafir E, LeBoeuf RA (2002) Rationality. *Annu Rev Psychol* 53:491-517. <https://doi.org/10.1146/annurev.psych.53.100901.135213>
- Shapiro L (2011) *Embodied Cognition*. Routledge, New York
- Sher, S, McKenzie, CR (2008) Framing effects and rationality. In: Chater N, Oaksford M (eds) *The probabilistic mind: Prospects for Bayesian cognitive science*. Oxford University Press, Oxford, p 79-96
- Sher S, McKenzie CR (2006) Information leakage from logically equivalent frames. *Cognition* 101(3):467-494. <https://doi.org/10.1016/j.cognition.2005.11.001>
- Sherman MA (1973) Bound to be easier? The negative prefix and sentence comprehension. *Journal of Verbal Learning and Verbal Behavior* 12(1):76-84. [https://doi.org/10.1016/S0022-5371\(73\)80062-3](https://doi.org/10.1016/S0022-5371(73)80062-3)
- Sorace A (2000) Gradients in auxiliary selection with intransitive verbs. *Language* 76(4):859-890. <https://doi.org/10.2307/417202>. 859-890
- Spivey M (2007) *The Continuity of Mind*. Oxford University Press, Oxford
- Stanovich KE, West RF (2008) On the relative independence of thinking biases and cognitive ability. *J Pers Soc Psychol* 94:672-695. <https://doi.org/10.1037/0022-3514.94.4.672>
- Stanovich KE, West RF (2000) Individual differences in reasoning: Implications for the rationality debate? *Behav Brain Sci* 23:645-665. <https://doi.org/10.1017/S0140525X00003435>
- Ströbel L (2019a) Le jaune de la discorde – Emmanuel Macron et les mouvements identitaires face à la crise des Gilets Jaunes. In: Issel-Dombert S, Wieders-Lohéac A (eds) *Die Krise als Krieg. Weltanschauungs- und Wortkampf populistischer Bewegungen in Krisenzeiten*. AVM, München, p 87- 106
- Ströbel L (2019b) The use of sensorimotor-based concepts during and after presidential campaigns: Emmanuel Macron and Donald Trump. In: Perrez J, Reuchamps M, Thibodeau PH (eds) *Variation in Political Metaphor. Discourse Approaches to Politics, Society and Culture* 85. John Benjamins, Amsterdam/Philadelphia, p131-150
- Ströbel L (2018a) *Sensomotorische Konzepte – Simulationsstrategien im französischen Wahlkampf*. In: Issel-Dombert S, Wieders-Lohéac A (eds). *Wahlkampf ist Wortkampf – Präsidentschaftswahlkampagnen aus sprachwissenschaftlicher Sicht*. Peter Lang, Berlin, p 249-268
- Ströbel L (2018b) Can Macromania be explained linguistically? Beneath the morphological boundary: A sketch of subconscious manipulation strategies in Emmanuel Macron's political discourses. *Yearbook of the German Cognitive Linguistics Association* 5(1):65-84. <https://doi.org/10.1515/ygla-2017-0005>
- Ströbel L (2017) The linguistic influence of perceptual and conceptual parameters. In: Wallington A, Foltz A, Ryan J (eds) *Selected Papers from the 6th UK Cognitive Linguistics Conference, Vol 4; The UK Cognitive Linguistics Association*, p 169-186
- Ströbel L (2016) (ed) *Sensory-Motor Concepts – at the Crossroads between Language & Cognition* Düsseldorf University Press, Düsseldorf
- Sudman S, Bradburn NM (1982) *Asking questions. a practical guide to questionnaire design*. Jossey-Bass Publishers, San Francisco, CA
- Swain SD, Weathers D, Niedrich RW (2008) Assessing three sources of misresponse to reversed Likert items. *Journal of Marketing Research* 45(1):116-131. <https://doi.org/10.1509/jmkr.45.1.116>
- Talmy L (1988) Force dynamics in language and cognition. *Cognitive Science* 12(1):49-100
- Thompson E, Cosmelli D (2011) Brain in a Vat or Body in a World? Brainbound versus Enactive Views of Experience. *Philosophical Topics* 39:163-180. p
- Thompson E (2007) *Mind in Life. Biology, Phenomenology, and the Sciences of Mind*. Harvard University Press, Cambridge (MA)
- Thompson E, Varela F (2001) Radical embodiment: Neural dynamics and consciousness. *Trends Cogn Sci* 5:418-425
- Tversky A, Kahneman D (1986) Rational choice and the framing of decisions. *Journal of Business* 59(4):251-278. <https://doi.org/10.1086/296365>
- Uhlmann EL, Leavitt K, Menges JI, Koopman J, Howe MD, Johnson RE (2012) Getting explicit about the implicit: A taxonomy of implicit measures and guide for their use in organizational research. *Organization Research Methods* 15:553-601
- Van Gorp B (2005) Where is the frame? Victims and intruders in the Belgian press coverage of the asylum issue. *Eur J Commun* 20(4):484-507
- Van Valin RD, LaPolla R (1997) *Syntax: Structure, Meaning and Function*. Cambridge University Press, Cambridge
- Van Valin RD (1993) *Advances in Role and Reference Grammar*. John Benjamins Publishing, Amsterdam, ed)
- Varela O (2005) *Morfología léxica: la formación de palabras*. Gredos, Madrid
- Varela FJ, Thompson E, Rosch E (1991) *The embodied mind: Cognitive science and human experience*. MIT Press, Cambridge (MA)
- Vendler Z (1967) *Linguistics in Philosophy*. Cornell University Press, Ithaca
- Vigliocco G, Kousta ST, Della Rosa PA, Vinson DP, Tettamanti M, Devlin JT, Cappa SF (2014) The neural representation of abstract words: The role of emotion. *Cereb Cortex* 24:1767-1777. <https://doi.org/10.1093/cercor/bht025>
- Vigliocco G, Vinson DP, Druks J, Barber H, Cappa SF (2011) Nouns and verbs in the brain: a review of behavioural, electrophysiological, neuropsychological,

- and imaging studies. *Neurosci Biobehav Rev* 35(3):407–426. <https://doi.org/10.1016/j.neubiorev.2010.04.007>
- Villarreal Ordenes F, Ludwig S, De Ruyter K, Grewal D, Wetzels M (2017) Unveiling what is written in the stars: Analyzing explicit, implicit, and discourse patterns of sentiment in social media. *J Consum Res* 43(6):875–894. <https://doi.org/10.1093/jcr/ucw070>
- Warriner AB, Kuperman V, Brysbaert M (2013) Norms of valence, arousal, and dominance for 13,915 English lemmas. *Behav Res Methods* 45(4):1191–1207. <https://doi.org/10.3758/s13428-012-0314-x>
- Watson CE, Cardillo ER, Ianni GR, Chatterjee A (2013) Action concepts in the brain: An activation likelihood estimation meta-analysis. *J Cogn Neurosci* 25:1191–1205. https://doi.org/10.1162/jocn_a_00401
- Weisberg HF (2005) *The total survey error approach: a guide to the new science of survey research*. The University of Chicago Press, Chicago
- Weisgerber L (1954/1973) *Die Sprachfelder in der geistigen Erschließung der Welt*. In: Schmidt L (ed) *Wortfeldforschung. Zur Geschichte und Theorie des sprachlichen Feldes*. Wissenschaftliche Buchgesellschaft, Darmstadt, p 318–335
- West RF, Toplak ME, Stanovich KE (2008) Heuristics and biases as measures of critical thinking: Associations with cognitive ability and thinking dispositions. *J Educ Psychol* 100:930–941
- Wierzbicka A (1996) *Semantic primitives*. Oxford University Press, Oxford
- Wilson M (2002) Six views of embodied cognition. *Psychol Bull* 9(4):625–636
- Wilson RA, Foglia L (2011) Embodied Cognition. *The Stanford Encyclopedia of Philosophy*. <http://plato.stanford.edu/archives/fall2011/entries/embodied-cognition/>
- Woolley AW, Chabris CF, Pentland A, Hashmi N, Malone TW (2010) Evidence for a collective intelligence factor in the performance of human groups. *Science* 330:686–688

Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by David Antons. The first draft of the manuscript was written by Liane Ströbel, Iring Koch, Torsten-Oliver Salge and David Antons, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Competing interests

The authors declare no competing interests.

Ethical approval

All procedures performed in the present study were in accordance with the Helsinki declaration and comparable ethical standard. The study was not approved by an ethics committee because no physical or psychological discomfort and harm due to the participation in this study was expected. Moreover, we did not use invasive methods and did not test underage persons or patients.

Informed consent

We conducted two studies using this experimental setup. Study 1 (10/2019) used a convenience sampling strategy while we conducted Study 2 (5/2021) with English native speakers from different English-speaking countries. In both studies, participants were first informed about the purpose of the study (to study a linguistic question of the understanding of two verbs) using a few survey items as well as a reaction time test. Next, we communicated how data were stored, analysed, and utilized for scientific publication. We also informed participants about European data security laws and their right to withdraw their consent. Lastly, participants were notified of the fact that they would not receive any payment for taking part in the survey. Only participants agreeing to these conditions were then forwarded to the study. All subjects provided written consent.

Additional information

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