ORIGINAL ARTICLE

The spatial grounding of politics

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Abstract

In three studies, we advance the research on the association between abstract concepts and spatial dimensions by examining the spatial anchoring of political categories in three different paradigms (spatial placement, memory, and classification) and using non-linguistic stimuli (i.e., photos of politicians). The general hypothesis that politicians of a conservative or socialist party are grounded spatially was confirmed across the studies. In Study 1, photos of politicians were spontaneously placed to the left or right of an unanchored horizontal line depending on their socialist-conservative party affiliation. In Study 2, the political orientation of members of parliament systematically distorted the recall of the spatial positions in which they were originally presented. Finally, Study 3 revealed that classification was more accurate and faster when the politicians were presented in spatially congruent positions (e.g., socialist politician presented on the left side of the monitor) rather than incongruent ones (e.g., socialist on the right side). Additionally, we examined whether participants' political orientation and awareness moderated these effects and showed that spatial anchoring seems independent of political preference but increases with political awareness.

Introduction

The political terms 'left' and 'right' originated in 1789 from the seating arrangement of the legislative bodies in the French National Assembly. The 'ancien régime' sat to the right of the president, the 'revolutionaries' to his left (cf. Gauchet & Taylor, 1999). This incidental spatial organization of politics has been with us ever since, condensing a variegated political spectrum (Ware, 1996) on the horizontal dimension. The studies reported here examined whether such an arbitrarily established spatial anchoring grounds how we represent and process stimuli that are associated with political positions. The research we report involves three experimental paradigms using stimuli (i.e., photos of

politicians) that are different from those used (i.e., predominantly semantic) in earlier research documenting the grounding of politics on the horizontal dimension. Additionally, we examine the role of two potential moderators, namely political orientation and political awareness, in driving the effect.

Previous research suggests that when a left orientation is induced by asking participants to lean to the left, a somewhat stronger liberal attitude is observed (Oppenheimer & Trail, 2010). Others reported faster classifications of left-wing party acronyms after a cue indicating a left-hand button press (and vice-versa for right-wing acronyms) as well as faster classifications of right-wing acronyms presented on the right side of the screen (van Elk et al., 2010). Farias et al. (2013) demonstrated that participants placed conservatism and socialism-related words correspondingly to a right or left spatial position on horizontal space. Furthermore, when those same words were presented equally loud to both ears, they were disambiguated as being louder to the ear that was congruent with the political position expressed by the word. Farias et al. (2016) also demonstrated that the spatial grounding of politics is independent of experimentally driven stimulus–response compatibility effects (e.g., horizontal vs. vertical response key assignments). Thus, apart from showing that a spatial relationship between political categories and the horizontal space exists, these results also

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indicate that this association is present across symbolic, visual, and auditory modalities.

Similar to abstract concepts such as "affect" or "time" that activate spatial associations (Crawford et al., 2006; Lakens et al., 2011; Woodin & Winter, 2018), the spatial left–right distinction in politics can be regarded as a linguistic metaphor. According to conceptual metaphor theory (Lakoff & Johnson, 2008), abstract metaphors are grounded by concrete, sensorimotor schemas. The repeated exposure to diverse media (e.g., exit polls or election outcomes represented on TV, newspapers, or websites) and other types of discourse in which politics is articulated referring to political parties, ideologies or personages as "left" or "right", establishes semantically driven spatial associations with distinctive features of the respective ideologies. The labels of left-wing, leftist, the left, or words like trade union and proletariat have become associated with socialism, communism, and social democracy. In contrast, the categories of right-wing, rightist, the right, as well as words like capitalism or stockmarket, refer to conservatives, monarchists as well as those supporting free-market capitalism, and some forms of nationalism. This means that our linguistic ecology (Semin, 2011) contains references to spatial anchors in political discourse.

However, are spatial source-domain representations abstracted from sensorimotor experiences, or are they instantiated via modality-specific simulation? A recent special theme issue on the development, use, and representation of abstract concepts in the brain (Borghi et al., 2018) suggests that the answer to this question depends on the kind of abstract concept in question (e.g., emotional concepts, evaluative concepts, numerical concepts, etc.) and the researcher's theoretical position. According to Borghi et al. (2017), two views currently define how scholars discuss the issue of abstract concept representation: a strong, grounded view and a multiple representation view. The strong, grounded view suggests that abstract concepts induce activity in neural cortices used for action, perception, and emotion. This view is supported by Action-Based Language theory (Ferguson & Hegarty, 1994; Franklin & Tversky, 1990; Taylor & Tversky, 1992); Conceptual Metaphor Theory (Lakoff & Johnson, 2008), Situation and Introspective theory (Barsalou & Wiemer-Hastings, 2005; Wiemer-Hastings & Xu, 2005), and an Affective Embodiment account (Kousta et al., 2011). Almost without exception, studies in support of these theoretical accounts show that abstract concepts with either a motor or visual feature content are grounded in sensorimotor systems (Horchak et al., 2014). For example, with regards to motor content, Sell and Kaschak (2012) showed that reading sentences with the concepts "more" and "less" led to quicker upward and downward directed responses, respectively. As another example, Horchak et al. (2016) found a relationship between metaphorical forward body movements

and approach-oriented posture in judgments related to such abstract concept as "competence". Regarding visual content, Harpaintner et al. (2020) recently used functional magnetic resonance imaging and assessed brain activation to abstract concepts strongly associated with certain visual features (e.g., beauty). The researchers found that processing of visual abstract words elicited higher activity in temporo-occipital visual areas, thus confirming a hypothesis that abstract concepts associated with visual processes are, in part, grounded in modality-specific brain systems typically engaged in actual perception. Thus, the case for the activation of motor and visual experiences in understanding some abstract concepts is strong.

Nonetheless, just demonstrating that processing abstract words relies on the activation of sensorimotor information does not provide sufficient reason to think that these concepts rely exclusively on sensorimotor input (Dove, 2018). Increasingly, researchers are directing more attention to how both symbolic and sensorimotor representations capture the meaning of linguistic material. As a result, the last decade witnessed a surge of interest in theoretical accounts clustered under the label multiple representation theories (Borghi et al., 2017), such as language and situated simulation (Barsalou et al., 2008), representational pluralism (Dove, 2009, 2016); words as social tools (Borghi et al., 2013, 2019); and symbol interdependency (Louwerse, 2008, 2011). On a general level, these accounts hold that information processing can proceed successfully only when both experiential and linguistic factors are considered. For example, there is fMRI evidence that the linguistic system and the simulation system jointly contribute to conceptual processing (Simmons et al., 2008). Furthermore, there is research showing that abstract concepts rely on linguistic input and concrete concepts rely on sensorimotor experience (Granito et al., 2015); abstract concepts activate the mouth-related system, and concrete concepts activate the hand-related motor system (Borghi & Zarcone, 2016); and the distributional structure of language itself (e.g., "bird" co-occurs with "sky" much more frequently than "dog") provides a rich source of prediction for the meaning of abstract concepts (Louwerse, 2008; Lupyan & Lewis, 2019). Thus, the processing of abstract concepts seems to involve a tight relationship among language-specific semantic operations and sensorimotor experiences.

As noted above, a great deal of empirical evidence points to the important role of linguistic processing in the representation of abstract concepts. Research on spatial relations is no exception to this idea. There is, in fact, well-documented evidence showing the effect of language in shaping spatial relations (Ferguson & Hegarty, 1994; Franklin & Tversky, 1990; Taylor & Tversky, 1992). An illustrative example of how spatial information is encoded in language is furnished by Louwerse and Zwaan (2009), who showed that the regular

co-occurrences of towns in our linguistic ecology (e.g., media) are sufficient to reproduce a geographical map with considerable accuracy. Specifically, the researchers found that corpus-based analyses using word co-occurences and frequencies provided estimates of geographical distances and population sizes that were similar to human estimates.

Thus, our linguistic ecology contains spatial information that is the unintended consequence of multiple speech acts by which a linguistic reality is constituted (cf. Semin, 2011). This leads to the conclusion that spatial associations with political positions and persons may depend on both embodied and linguistic processing.

Opposing political orientations are often represented with recourse to linguistic terms, and research conducted in this field has mostly relied on linguistic stimuli. However, as discussed by Louwerse and Jeuniaux (2010), linguistic stimuli (i.e., words) require shallower processing than non-linguistic stimuli like pictures, thus setting up a challenge to understand the interplay between spatial information and concept processing in deeper cognitive tasks. Therefore, a crucial issue is whether the spatial grounding of political categories occurs routinely, or alternatively, the association between abstract political concepts and spatial dimensions emerges only when the task strongly encourages linguistic processing. Specifically, it is possible that previous results are predictable from corpus-derived language statistics, namely, how frequently particular concepts are mentioned as being left or right.

Nonetheless, according to the words as social tools (WAT) account (Borghi & Binkofski, 2014), the acquisition of abstract concepts proceeds not only through linguistic input, but also through sensorimotor experience. If this is the case, abstract concepts related to the left and right dimensions should have diverse referents. Accordingly, it is conceivable that thinking about words that have to do with socialism and conservatism, such as, for example, "trade union" and "stock market", as used in previous research, may lead to the activation of linguistically acquired information. However, using the pictures of political leaders, as in the present research, may activate both linguistically and visually acquired information. Consequently, it remains unclear whether the spatial relation between political position and space is as important when an abstract political concept is associated with a concrete referent (i.e., photo of a popular politician) that is likely to activate the perceptual system. Studying the grounding of political space using pictorial stimuli is well suited to address this question as participants would have to use visual features from the pictures to make their decision.

The current research was therefore designed to address this issue (1) using non-linguistic stimuli and different experimental paradigms, and (2) by conceptually replicating the pattern of findings from earlier research in the same thematic domain (Farias et al., 2013; Oppenheimer & Trail, 2010; van Elk et al., 2010). More specifically, throughout three experiments, we investigated whether people represent and process non-linguistically presented political stimuli (i.e., photos of politicians) with reference to a horizontal spatial dimension. The relevance and novelty of introducing this type of stimuli is to show that the spatial grounding of political categories is still manifested when non-linguistic exemplars of these categories are used.

Moreover, we examined this phenomenon across such different cognitive tasks as (1) spatial location, (2) recall, and (3) classification. In the first task, participants positioned the photos of (socialist or conservative) politicians on an unanchored horizontal line as they thought "most people would". In the second task, participants saw politicians' photos (presented equally frequently to the left and right sides of the monitor) and were asked to recall on which side (left or right) these were presented more frequently. In the third task, participants saw the photos of politicians on the right and left sides of the monitor and classified them as either socialist or conservative. The idea behind varying the task was to demonstrate that the link between politicians' party membership and left and right spatial orientation is not task-dependent.

Such conceptual replication studies are useful in generalizing the original findings in different contexts and testing the stability of specific empirical phenomena. This issue is currently at the heart of a controversial but meaningful debate that contributes to the development of reliable and cumulative knowledge (Ijzerman et al., 2013; Landy et al., 2020; Pashler & Wagenmakers, 2012). Nevertheless, a close replication does not contribute substantially to the broader generalization of a given psychological finding. As Westfall et al. (2015) pointed out, the importance of replication studies also rests on new samples (to control for potential sampling error) and also in the introduction of new stimulus materials in order to obtain evidence that findings in an experiment are not biased by the stimuli themselves.

Additionally, our goal was to extend the growing body of research on the spatial representation of abstract concepts by investigating moderators (cf. Landau et al., 2010), namely participants' political orientation and awareness. Political orientation can bias the processing of political stimuli (e.g., recall, classification). For instance, one's own position may serve as an anchor or reference point in social perception (Sherif & Hovland, 1961). Earlier findings (e.g., (van Elk et al., 2010) indicate a correlation between participants' preference for right-wing parties (vs. left-wing parties) and the size of the effects observed in their classification of left-wing parties. Participants' political orientation may also induce a positive bias for photos of preferred politicians towards the right (see Casasanto, 2009, on the association between spatial left–right and negative–positive valence). Finally,

participants' political affiliation may even make participants more or less prone to follow the politician's gaze with the same political orientation (Liuzza et al., 2011). However, if the association between political positions and the left–right spatial dimension derives from a shared spatial metaphor as well as a shared referential base, then these associations should hold, irrespective of one's own political preference. Political awareness is expected to amplify the metaphoric link between left and right-wing-related concepts and space. Politically aware participants are likely to be more frequently exposed to the left–right categorization. Consequently, these categories should be more salient and accessible to them (cf. Higgins, 1996) and therefore amplify their judgments (Higgins & Brendl, 1995) regarding the left–right differentiations between location, recall, and classification of politicians.

Overview

Across the three experiments reported below, we used similar stimulus materials and the same moderator variables. All procedures were executed in compliance with the relevant ethical guidelines and were approved by the ethics committee. All participants gave written informed consent for their participation.

A power analysis was done in G*Power using the results of thematically related research of van Elk et al. (2010) and Oppenheimer and Trail (2010), where large effect sizes ($\eta^2 = 0.14$ or more) were reported for the critical interactions of interest. To reduce the unknown risk of anticonservativity, we used a medium effect size of $\eta^2 = 0.08$ to calculate the required sample size. The analysis indicated that we would need a minimum of 45 participants to find an effect if there is one ($\alpha = 0.05$, power $= 0.80$). To ensure each of our experiments had sufficient power after potential exclusions, we always attempted to recruit at least 50 participants.

The stimulus materials consisted of passport type black and white photos of left and right-wing politicians taken from the Portuguese parliament's website.[1] A pilot-study ($N = 50$) with 48 photos of politicians revealed that a subsample of 12 politicians displayed in the photos were highly familiar ($M = 6.07$, SD $= 0.70$), as indicated by their ratings on a 7-point familiarity scale (1-not familiar/7-very familiar), which differed significantly from the scale midpoint, $t(49) = 20.98$, $p < 0.001$. The same pilot-study showed for this subsample, on a 7-point political orientation scale (1-left-wing/7-right-wing), that six left-wing politicians were rated significantly below ($M = 2.31$, SD $= 1.23$),

$t(45) = -9.31$, $p < 0.001$; and six right-wing politicians were rated significantly above the scale midpoint ($M = 5.39$, SD $= 1.30$), $t(48) = 7.46$, $p < 0.001$. These 12 photos constituted the pool of critical stimuli in the 3 experiments.

Political awareness was assessed by 18 items measuring political interest, engagement, and knowledge (European Values Survey, 2000). Political orientation was assessed with a 7-point scale (1-left-wing/7-right-wing). The data regarding participants' political awareness and political orientation from Experiments 1–3 are provided in "Appendix 1".

With regards to statistical analyses, we used mixed-effects modeling to examine the spatial anchoring of political categories. There are two major advantages of using this kind of analysis. First, whereas previous thematically similar research considered only one random variable (participants in the so-called F_1 analyses) in the design, mixed-effects models allowed us to estimate both participants and stimuli as random effects. Second, mixed-effects models permitted us to take into account all "raw" participant responses rather than mean responses, and hence are more powerful (Brysbaert & Stevens, 2018). All analyses were conducted with R Version 4.0.5 (R Core Team, 2019). The package tidyverse (Wickham et al., 2017) was used for data wrangling; the packages lme4 (Bates et al., 2015), lmerTest (Kuznetsova et al., 2017), and interactions (Long, 2019) were used for statistical analyses. In all analyses, we attempted to fit the "maximal" model consistent with the experimental design. If the "maximal" model failed to converge or was found to be overfitted (e.g., a singular fit warning in R), we removed random terms to allow for a convergence or non-singular fit (see Barr et al., 2013, for discussion). Finally, in the analysis of all experiments, all categorical predictors were deviation-coded ($-1 =$ right side and/or right position, $1 =$ left side and/or left position) to facilitate the interpretation of main effects in the presence of interactions.

Experiment 1

In a free spatial ordering paper–pencil task, Portuguese-speaking participants were asked to position photos of (socialist or conservative) politicians on a horizontal line. We predicted that party membership of the politicians would affect these placements, with socialist politicians placed more to the left and conservative politicians to the right.

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[1] The photos of politicians used were taken from the following parliamentary website: https://www.parlamento.pt/DeputadoGP/Paginas/Deputados.aspx. However, the parliament changes at least every 4 years, so it is possible that not all the photos of politicians we have used are still available.

Method

Participants and procedure

Ninety[2] university students (64 females; $M_{age} = 22.94$) received 2 randomized sets of pretested photos of 8 politicians each (3 socialist, 3 conservative, and 2 fillers—unknown politicians' photos, in each set) and were asked to place them on a horizontal line (with 8 possible fixed spatial positions to distribute the 8 photos) as they thought "most people would". The task was repeated with a second set of photos. Finally, participants responded to the measures of political orientation and awareness.

Results and discussion

Overall, participants placed politicians' photos in line with politicians' political positions 56% of the time. Spatial placement of the politicians' photos as the dependent variable was estimated using a linear mixed-effects regression model. The best non-singular model that converged successfully included politicians' party membership as a fixed effect and a by-item intercept as a random effect. The results showed that politician's party membership was not a significant predictor (estimate $= -0.28$, SE $= 0.22$, $t = -1.25$, $p = 0.24$, 95% CI $[-0.71, 0.16]$) in spite of the fact that socialist politicians were, as expected, placed more to the left ($M = 4.13$, SD $= 2.31$) of conservative politicians ($M = 4.68$, SD $= 2.36$). However, introducing participants' political orientation and political awareness ($\alpha = 0.793$) to the model as additional predictors (both z-transformed) revealed a significant interaction between the politician's party membership and the participant's political awareness (estimate $= -0.33$, SE $= 0.07$, $t = -4.86$, $p < 0.001$, 95% CI $[-0.46, -0.20]$). As shown in Fig. 1, a simple slopes analysis revealed that participants with high-political awareness placed conservative politicians and socialist politicians significantly more to the right and left, respectively (estimate $= 1.19$, SE $= 0.47$,
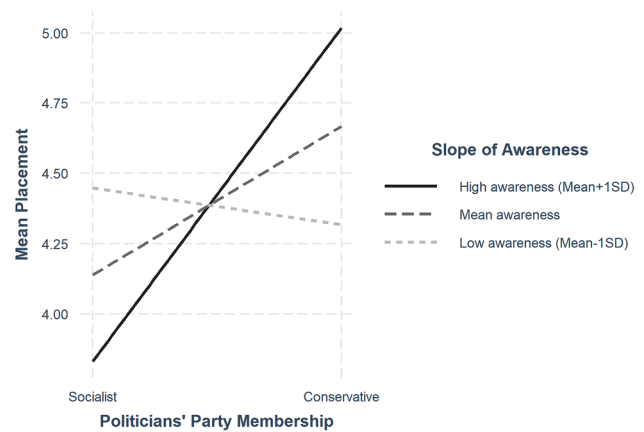

Fig. 1 Average spatial placement of the politicians' photos as a function of politician's party membership. Lower placement scores are closer to the left-hand side in space, and higher placement scores are closer to the right-hand side in space

$t = 2.50$, $p = 0.03$). In contrast, participants with low political awareness did not differ significantly in how they placed politicians' photos on a horizontal line (estimate $= -0.13$, SE $= 0.47$, $t = -0.28$, $p = 0.79$). Thus, the link between party membership of the politicians and their spatial placement was observed only for participants with a high level of political awareness.

Experiment 2

The second experiment, conducted in E-Prime, was designed to examine whether a politician's party membership distorts recalling the perceived position of where a politician's photo was presented spatially. Politicians' photos were presented equally frequently to the left and right sides of the monitor. Participants' task was to recall on which side each politician had been presented more frequently. We predicted that a memory bias would be observed, namely that socialist politicians would be remembered as having been presented more frequently on the left, and conservative politicians would be remembered as having been presented more often to the right.

Method

Participants and procedure

Fifty-two Portuguese university students (46 females; $M_{age} = 20.04$) saw 12 critical (socialist and conservative politicians) and 20 additional filler photos (unknown politicians). Each critical photo was presented four times (twice on the left and twice on the right side of the monitor) for 3000 ms. The filler photos were randomly presented (one,

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[2] As we were assigned a larger subject pool than expected, participants in Experiment 1 exceeded the sample size suggested by the power analysis. To ensure that the effect holds up to empirical scrutiny with a sample size suggested by power analysis, we removed the 40 last-run participants from Experiment 1, and thus equated the number of participants per experiment. In short, the analyses run on the data from 50 participants showed an almost identical pattern of results as the analyses run on the data from 90 participants. Specifically, the results showed that politician's party membership was not a significant predictor (estimate $= -0.28$, SE $= 0.22$, $t = -1.29$, $p = .23$, 95% CI $[-0.71, 0.15]$) of participants' responses. However, introducing participants' political orientation and political awareness to the model as additional predictors revealed a significant interaction between the politicians' party membership and participants' political awareness (estimate $= -0.30$, SE $= 0.09$, $t = -3.30$, $p = .001$, 95% CI $[-0.48, -0.12]$).

two, three, or four times) on the left or the right side of the monitor. There were a total of 144 trials (48 critical and 96 filler). Subsequently, at the test phase, participants were shown the critical photos at the center of the screen and asked to indicate the most frequent location (left or right) in which each photo had been presented. Finally, they completed the political orientation and awareness measures.

Results and discussion

Participants recalled the position at which the politicians were presented in line with politicians' party membership 57% of the time. Regarding the main analysis, logistic mixed-effects regression was used to estimate the probability of participants recalling the side at which the critical stimuli were presented. The reference level of the dependent variable was set to "right side," and thus, the coefficients below report the changes in the odds of observing a "left-side" response. The best non-singular model that converged successfully (with politicians' party membership as a fixed effect and intercept for items as a random effect) showed that the probability of recalling a stimulus presented on the left side significantly increased for socialist politicians ($M = 0.58$, SD = 0.49) rather than conservative ($M = 0.45$; SD = 0.50), estimate = 0.27, SE = 0.10, $z = 2.74$, $p = 0.006$, 95% CI [0.08, 0.47]). Participants' orientation and awareness ($\alpha = 0.833$) did not moderate the results ($z < 2$). The possible reasons for this are presented in the general discussion.

Experiment 3

In Experiment 3, conducted in E-Prime, participants had to quickly classify a set of politicians' photos as either socialist or conservative. This task was used to inform us about the potentially automatic nature of the spatial anchoring process and prevent participants from easily transducing the visual stimuli to linguistic representations. We predicted higher accuracy and faster classification times when party membership and politicians' presentation position coincide.

Method

Participants and procedure

Fifty Portuguese university students (44 females; $M_{age} = 20.04$) were asked to classify the photos of well-known politicians as rapidly and accurately as possible as socialist or conservative by pressing the "U" and the "N" keys using their index fingers (counterbalanced across participants). These keys (orthogonal to the horizontal spatial dimension) were used to avoid congruence between response key position and party membership. Participants

were presented with photos of eight politicians (four socialist and four conservative) and four fillers (other unknown politicians). Each photo was presented 6 times: 3 times to the right and thrice to the left side of the monitor giving rise to 72 trials. Participants' political orientation and awareness were also assessed.

Results and discussion

Accuracy analysis

Mixed-effects logistic regression model was used to analyze participants' accuracy. The reference level of the dependent variable was set to incorrect response, and thus, the coefficients below report the changes in the odds of observing a correct response. Prior to analysis, we discarded the responses of one participant for having extremely low accuracy[3] (10% only). The best non-singular model that converged successfully included politician party membership (socialist vs. conservative), screen side (left vs. right), and their interaction as fixed effects; as well as by-participant and by-item random intercepts and a by-participant slope for politicians' party membership as random effects. Participants' overall accuracy was 67%. The only significant result was an interaction between politician party membership and screen side (estimate = 0.16, SE = 0.05, $z = 3.42$, $p = 0.001$, 95% CI [0.07, 0.25]). To get a sense of the interaction effect, we used dummy coding of the party membership factor to obtain simple effects of screen side for socialist and conservative politicians, respectively. The analysis showed that participants classified socialist politicians more accurately when they appeared on the left ($M = 0.71$, SD = 0.46) rather than the right ($M = 0.65$, SD = 0.48) side (estimate = 0.15, SE = 0.07, $z = 2.36$, $p = 0.019$, 95% CI [0.03, 0.28]). Similarly, participants classified conservative politicians more accurately when they appeared on the right ($M = 0.69$, SD = 0.46) rather than the left ($M = 0.63$, SD = 0.48) side (estimate = -0.16, SE = 0.07, $z = -2.48$, $p = 0.013$, 95% CI [-0.29, -0.03]). Finally, participants' political orientation and political awareness ($\alpha = 0.833$) did not significantly

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[3] We excluded this participant's data as the accuracy of only 10% would lead to the removal of 90% of observations during the analysis of response times, where only correct responses were considered. The analysis done on the accuracy data including this participant revealed an almost identical pattern of results. Specifically, there was a significant interaction between politicians' party membership and screen side (estimate = 0.16, SE = 0.05, $z = 3.44$, $p = .001$, 95% CI [0.07, 0.25]), reflecting the fact that participants classified socialist politicians more accurately when they appeared on the left side (estimate = 0.15, SE = 0.06, $z = 2.35$, $p = .019$, 95% CI [0.02, 0.28]); and conservative politicians when they appeared on the right side (estimate = -0.16, SE = 0.06, $z = -2.53$, $p = .012$, 95% CI [-0.29, -0.04]).
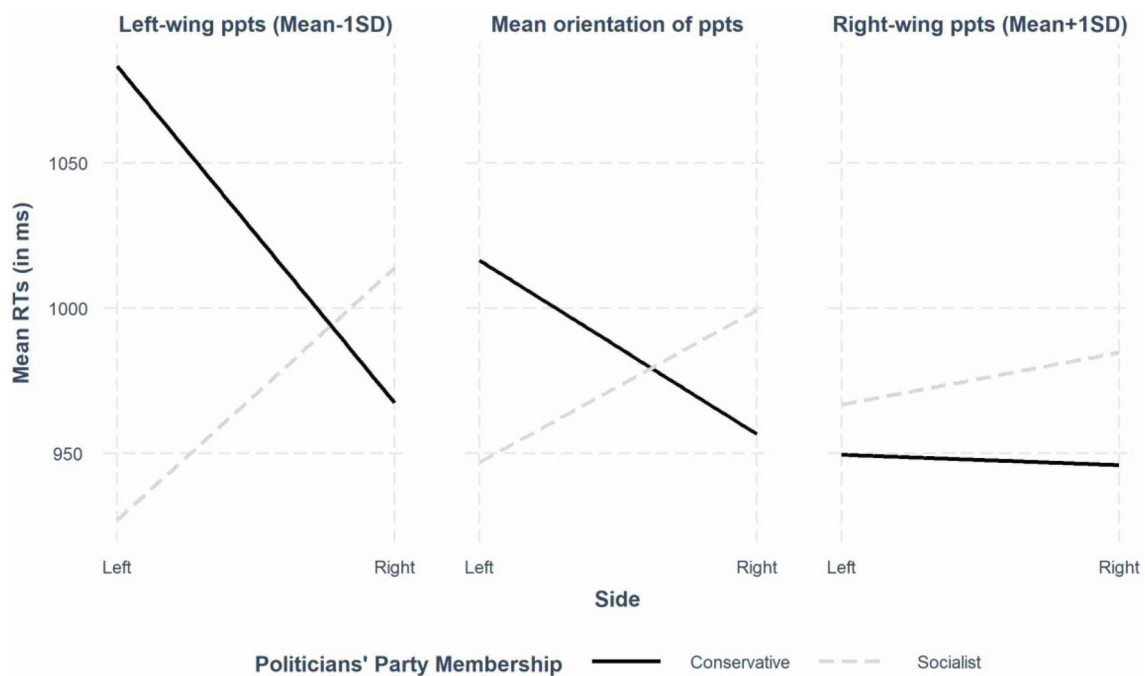
Fig. 2 Raw response times as a function of politicians' party membership, screen side, and participants' political orientation *ppts* participants

moderate participants' accuracy (three-way interactions including awareness and orientation had z values < 2).

Response times (RTs) analysis

Participants' RTs were analyzed using a linear mixed-effects regression model, which included the same fixed and random effects as in the just-mentioned model used to analyze accuracy. Prior to analyses, incorrect responses or responses with RTs faster than 300 ms or slower than 3000 ms were excluded. We then removed responses with RTs 2.5 SD lower or higher from each trial's mean. RTs were standardized by subtracting the mean and dividing by SD for analysis. Finally, after outlier treatment, the responses of two participants had to be discarded for having only one valid RT response at certain levels of the factor, which usually leads to a non-convergence of the model (see Barr et al., 2013, for discussion). The results showed that the only significant effect was the interaction between politicians' party membership and screen side (estimate = − 0.07, SE = 0.02, t = − 3.09, p = 0.002, 95% CI [− 0.12, − 0.03]). As in the accuracy analysis, we used dummy coding of the party membership factor to obtain simple effects of screen side for socialist and conservative politicians, respectively. The data showed that socialist politicians were classified faster on the left (M = 938, SD = 363) rather than the right (M = 999, SD = 415) side (estimate = − 0.07, SE = 0.03, t = − 2.13, p = 0.033, 95% CI [− 0.14, − 0.01]). Similarly, conservative politicians were classified faster on the right (M = 960,

SD = 356) rather than the left (M = 1014, SD = 418) side (estimate = 0.08, SE = 0.03, t = 2.24, p = 0.025, 95% CI [0.01, 0.14]).

Introducing participants' political orientation and political awareness (α = 0.833) to the model as predictors (both z-transformed) revealed that there was a significant three-way interaction between politician party membership, screen side, and participants' political orientation (estimate = 0.06, SE = 0.02, t = 2.42, p = 0.016, 95% CI [0.01, 0.11]). Furthermore, there was also a significant three-way interaction between the party membership of the politician, screen side, and participants' political awareness (estimate = − 0.06, SE = 0.02, t = − 2.32, p = 0.020, 95% CI [− 0.10, − 0.01]). As shown in Fig. 2, a simple slopes analysis indicated that for left-oriented participants RTs were faster when left-wing politicians were on the left side rather than the right side (estimate = 0.22, SE = 0.10, t = 2.32, p = 0.02). Similarly, for left-oriented participants RTs were faster when right-wing politicians were on the right-side rather than the left side (estimate = − 0.30, SE = 0.09, t = − 3.15, p < 0.001). However, for right-oriented participants RTs did not differ significantly depending on the side and political position of politicians (t < 1).[4]

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[4] Notably, truly right-wing participants made up only about 14% of the sample (see "Appendix 1"), and therefore these results should be interpreted with caution. Further statistical analyses regarding the moderating role of political orientation and awareness in spatial-grounding effects are provided in "Appendix 2".
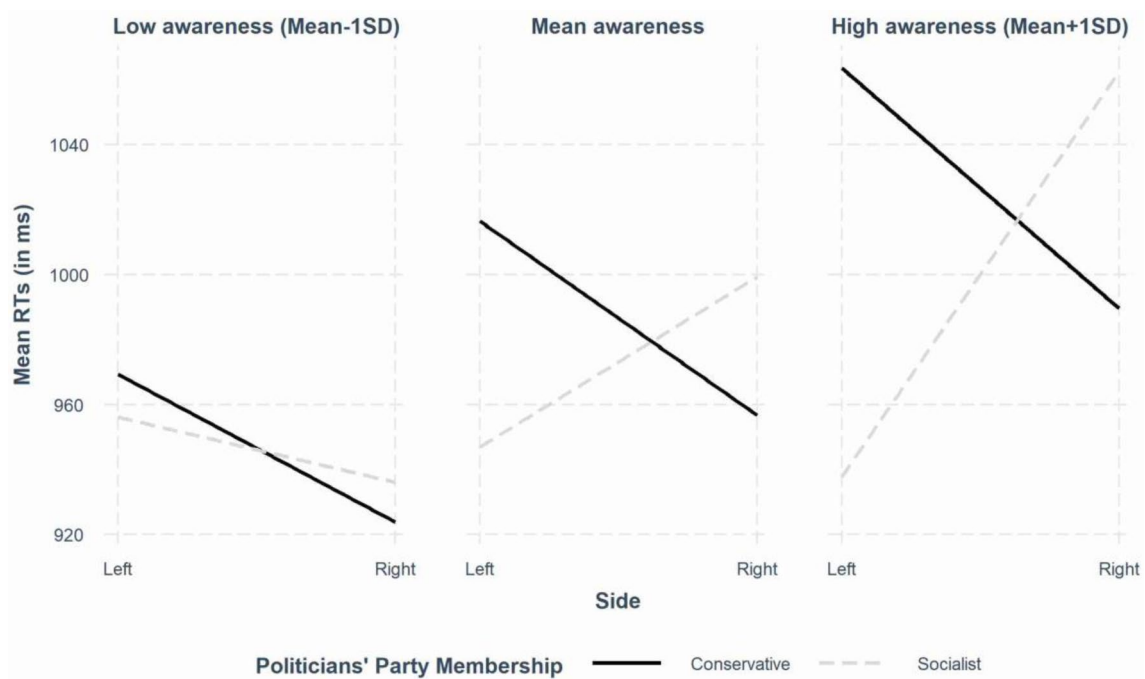
Fig. 3 Raw response times as a function of politicians' party membership, screen side, and participants' political awareness

Finally, as shown in Fig. 3, there were no statistically significant differences in RTs as a function of screen side and politician's party membership for participants with low political awareness ($t < 2$). However, there were statistically significant differences in RTs for participants with high political awareness. Specifically, RTs were faster when socialist politicians appeared on the left side rather than the right side (estimate = 0.32, SE = 0.09, $t = 3.41$, $p < 0.001$). Similarly, RTs were faster when conservative politicians appeared on the right side rather than the left side (estimate = − 0.19, SE = 0.10, $t = − 1.98$, $p = 0.05$). Thus, these results give further credence to our argument about the boundary conditions to the involvement of spatial metaphors in representations of political concepts.

General discussion

In three experiments, we confirmed that a horizontal spatial dimension grounds the representation of non-linguistic stimuli associated with the political left and right. In a free ordering task, participants with high political awareness (compared to those with low awareness) placed photos of conservative politicians more to the right than socialist politicians. When photos of politicians were presented equally frequently on the right or left side, participants with both high and low political awareness remembered conservative politicians as having been presented more often on the right side and the reverse for socialist politicians. Finally,

participants were more accurate and faster (particularly left-oriented ones and those with high political awareness) in categorizing politicians as conservative when they were presented on the right than on the left (socialist politicians were categorized faster and more accurately when they appeared on the left).

Previous research on politics-space associations has already provided evidence for this association (e.g., Farias et al., 2013; Oppenheimer & Trail, 2010; van Elk et al., 2010). However, most of these studies involved linguistic stimuli. The consistent pattern of the current findings lends additional support to previous results, indicating that the political polar opposites "left" and "right" are spatially represented and suggests that this association is obtained with visual political stimuli, thus adding generalizability to the observed effects.

In contrast to previous studies (van Elk et al., 2010), we did not find consistent moderation effects due to participants' political orientation. Participants' orientation was a significant predictor only in Experiment 3 with regard to RTs. Specifically, we found that right-wing participants (compared to left-wing) did not associate politicians' party membership with a left–right visual orientation. It is thus possible that the effect of participants' political orientation on political perceptions may only be detected with more sensitive measures such as response times. However, due to the limited sample of right-wing participants, future research is needed to answer this question more satisfactorily. Collectively, the findings from all three experiments demonstrate that being

left or right-wing does not considerably affect the processing of the political stimuli across different tasks. These findings suggest that the association between two opposed political and left–right spatial referents reflects the activation of spatial metaphors. In most situations, this association seems to hold irrespective of one's own political preferences or other valence-driven associations to horizontal spatial positions.

Moreover, participants who were politically more aware placed the politicians in a more polarized way on the horizontal dimension (Study 1) and were faster in classifying them in the respective conservative vs. socialist categories (Study 3). Participants who are more aware of politics are likely to be more knowledgeable and confident in their judgments. Substantial research indicates that the more confident one is, the more extreme one's judgment is (e.g., Tesser & Leone, 1977). Moreover, as argued in the introduction, these categories should be more accessible (cf. Higgins, 1996) to participants who are more aware of politics and more likely to amplify their judgments (cf. Higgins & Brendl, 1995). We find no such moderator effects in Study 2 and in the accuracy analysis of Study 3. In Studies 1 and 3, the categorical association can be expressed on a continuum. However, in the recall task used in Study 2 and the accuracy task in Study 3, the response options were binary (and thus limited). This response constraint prohibits the possibility of observing polarization as a function of political awareness, as the results also suggest. The fact that spatial grounding of political stimuli is mainly observed for politically aware participants suggests that metaphoric political representations are not universally shared—if the association is learned, then congruent biases are observed between spatial anchors and socialist and conservative political positions. However, when people are politically unaware, then this is not observed. These results resonate with a recent finding on the concept of gender (Mazzuca et al., 2020), showing that people stress distinct aspects of the gender concept as a function of specific life experiences.

The role of space in grounding abstract concepts has been examined predominantly with linguistic stimuli. The present findings support and extend this research by providing additional evidence that some abstract concepts are represented spatially beyond linguistic associations and underline the general argument that the spatial relationship between political categories and the horizontal space is likely activated by both symbolic and modal representations (see Farias et al., 2013).

An important qualification of the present study is that it does not provide direct evidence for the claim that the left–right political mapping relies on sensorimotor experiences. Although the role of grounding was previously shown to be superior for non-linguistic stimuli than linguistic stimuli (Louwerse & Jeuniaux, 2010), strong evidence for sensorimotor processing requires controlling for people's prior

experiences. On one hand, the left–right seating arrangement still prevails in the Portuguese parliament, and it is possible that people might be exposed to political party seating arrangements in the parliamentary hemicycle or elsewhere that preserve the left–right spatial layout. On the other hand, participants from the present research reside in a country where they are repeatedly exposed to expressions of "left" and "right" in the media that establish semantically driven spatial associations with distinctive features of the respective ideologies. Therefore, when placed alongside other sources of evidence reviewed earlier, the results seem to be consistent with a multiple representation view suggesting that the exposure to both linguistic and non-linguistic information underlies abstract concept formation.

Moreover, it is also important to mention why extending previous research to visual perception increases our understanding of the association between political categories and the left–right visual dimension. First, it helps us to uncover whether the effect is task-dependent. Notably, some previous research showed that embodied and linguistic factors affect conceptual processing differently depending on the task and stimuli. For example, Louwerse and Jeuniaux (2010) first asked one group of participants to estimate the likelihood that pictorial stimuli appear above one another in the real world, with some stimuli being presented in iconic order (e.g., attic above basement) and others in reverse-iconic order (e.g., basement above attic). Additionally, they measured the word order frequency of these stimuli in language. Then, they asked another group of participants to make speeded judgments on the semantic similarity of picture pairs (e.g., attic above basement vs. basement above attic) presented on a computer screen. The researchers found that participants' iconicity ratings (akin to embodied factor) predicted response times much better than word order frequencies (akin to linguistic factor). However, an almost identical experiment with word stimuli (instead of pictures) showed the opposite patterns of results: word order frequencies predicted response times better than iconicity ratings. Another reason for the need to assess the spatial grounding of politics using a diverse set of methods and stimuli concerns theory construction and development. All multiple representation theories suggest an interplay between semantic and perceptual properties during conceptual processing. Still, they are currently underspecified regarding the variability of the different kinds of abstract concepts. Specifically, it is conceivable that for some abstract concepts, linguistic experience is more important than embodied or social experience. At the same time, for other abstract concepts, the reverse may be true (see the reviews of Conca et al., 2021; Mazucca et al., 2021, for a related discussion). Thus, the main contribution of this work is that it establishes for the first time that the

association between political orientation and visual space does not depend on the nature of the task and stimuli; and that both linguistic and perceptual experiences contribute to the formation of abstract concepts related to politics.

Finally, the investigation of moderators may also extend our knowledge of the nature of these associations. As our results reveal, the association between spatial dimensions and political position holds (almost) irrespective of political preferences. This may reflect an important functional property of language, which allows efficient communication: despite one's political preferences, one has to communicate about political concepts using identical conceptual metaphors. The arbitrary nature of the spatial political metaphor is further underlined by results on the moderation of political awareness. Our findings show that, overall, those politically unaware do not process political information in the same way.

In conclusion, this research extends previous work documenting how abstract political concepts are represented in space using visual stimuli. The further examination of the relations between conceptual and spatial referents using different sets of stimuli and paradigms contributes to the reliability of the generalizability of the phenomenon. Finally, the identification of moderators, namely other individual and cultural ones, may contribute to our understanding of how these associations are established.

Appendix 1

Participants' distribution (in proportions) according to their levels of political orientation and awareness in Experiments 1–3.

Experiment	Orientation			Awareness		
	Left (%)	Center (%)	Right (%)	Low (%)	Average (%)	High (%)
Exp. 1	36	30	34	21	2	77
Exp. 2	54	29	17	52	4	44
Exp. 3	55	31	14	55	4	41

Participants' levels of political orientation and awareness were assessed with 7-point scales (political orientation: 1 = left and 7 = right; political awareness: 1 = very low; 7 = very high). Therefore, participants with average scores below 4 were considered left-oriented and with low political awareness; and with average scores above 4 were considered right-oriented and with high political awareness. Participants with mean scores of 4 were considered as being at the center of the political spectrum and having an average political awareness.

Table 1 The performance indices of the models used in Experiment 3

Model	Number of parameters	AIC	BIC	LogLik	Deviance
Model 1	12	3846.8	3910.0	− 1911.4	3822.8
Model 2	13	3840.4	3908.9	− 1907.2	3814.4
Model 3	12	3846.4	3909.6	− 1911.2	3822.4
Model 4	13	3839.5	3907.9	− 1906.8	3813.5
Model 5	16	3841.7	3925.9	− 1904.8	3809.7
Model 6	17	3837.8	3927.3	− 1901.9	3803.8

The difference between model 1 (scaled.RT ~ side * position + position * zscore.awareness + side * zscore.awareness) and model 2 (scaled.RT ~ side * position * zscore.awareness) was significant, $\chi^2(1) = 8.43$, $p = 0.004$. The difference between model 3 (scaled.RT ~ side * position + position * zscore.orientation + side * zscore.orientation) and model 4 (scaled.RT ~ side * position * zscore.orientation) was significant, $\chi^2(1) = 8.92$, $p = 0.003$. The difference between model 5 (scaled.RT ~ position * zscore.orientation + side * zscore.orientation + side * position * zscore.awareness) and model 6 (scaled.RT ~ side * position * (zscore.orientation + zscore.awareness)) was significant, $\chi^2(1) = 5.85$, $p = 0.016$

Appendix 2

Exploratory analyses

In Experiment 3, we found a significant interaction between participants' political orientation, screen side, and politicians' party membership for response time data. However, right-wing participants made up only about 14% of the sample, and it is, therefore, difficult to determine the strength of this moderation effect. To quantify the amount of evidence in favor of an effect of political orientation on participants' responses, we performed likelihood ratio comparisons using the anova function in R.

First, we checked whether a three-way interaction between the side, political position, and political awareness contributes to increased predictive accuracy. To this end, we compared the model that includes all possible main effects, two-way interactions, and a three-way interaction (R syntax of fixed effects: scaled.RT ~ side * position * zscore.awareness) with the model that includes all possible main effects and two-way interactions (scaled.RT ~ side * position + position * zscore.awareness + side * zscore.awareness). As shown in Table 1 (model 1 vs. model 2), the estimates of prediction accuracy favored model 2 that includes a three-way interaction.

Second, we checked whether a three-way interaction between the side, political position, and political orientation contributes to increased predictive accuracy. To this end, we compared the model that includes all possible main effects, two-way interactions, and a three-way interaction (scaled.RT ~ side * position * zscore.orientation) with the model that includes all possible main effects and two-way

interactions (scaled.RT ~ side * position + position * zscore.orientation + side * zscore.orientation). As shown in Table 1 (model 3 vs. model 4), the estimates of prediction accuracy favored model 4 that includes a three-way interaction.

Third, we checked whether a three-way interaction between the side, political position, and political awareness together with a three-way interaction between the side, political position, and political orientation contribute to increased predictive accuracy, compared to when only a three-way interaction between the side, political position, and political awareness is considered. To this end, we compared the model that includes all possible main effects, two-way interactions, and two three-way interactions (scaled.RT ~ side * position * (zscore.orientation + zscore.awareness)) with the model that includes all possible main effects, two-way interactions, and only one three-way interaction (scaled.RT ~ position * zscore.orientation + side * zscore.orientation + side * position * zscore.awareness). As shown in Table 1 (model 5 vs. model 6), the Akaike information criterion (AIC) favored model 6 that includes two three-way interactions. At the same time, the Bayesian information criterion (BIC) favored model 5 that includes only one three-way interaction. Thus, the result of political orientation for representation of the political space needs to be interpreted with caution.

Availability of data, material, and code All data and analysis scripts are openly available at the website of the Open Science Framework (https://osf.io/st7h4/?view_only=7c71d87c136249d184855617179482ce).

Declarations

Conflict of interest The funders had no role in study design, data collection and analysis, decision to publish, or manuscript preparation.

Ethics approval The current research was conducted in line with the ethical guidelines of the host institution.

Consent to participate (include appropriate statements) Informed consent was obtained from participants prior to their participation.

Consent for publication (include appropriate statements) We grant the publisher the right to publish this work should it be accepted for publication after the peer-review process.

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