The Influence of Language on Memory for Object Location

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Abstract

In this study, the influence of two types of language on memory for object location was investigated: demonstratives (*this, that)* and possessives (*my, your*). Participants read instructions (containing *this/that/my/your/the*) to place objects at different locations. They then had to recall those object locations. Experiments 1 and 2 tested the contrasting predictions of two possible accounts of language on memory: the *expectation* model (Coventry, Griffiths, & Hamilton, 2014) and the *congruence* account (Bonfiglioli, Finocchiaro, Gesierich, Rositani, & Vescovi, 2009). In Experiment 3, the role of attention as a possible mechanism was investigated. The results across all three experiments show striking effects of language on object location memory; objects in the "*that"* and "*your"* condition were misremembered to be further away than objects in the "*this"* and "*my"* condition. The data favored the expectation model: expected location cued by language and actual location are concatenated leading to (mis)memory for object location.

Keywords: memory for object location; spatial demonstratives; possessives

Introduction

Language is often used to direct the attention of a conspecific to the spatial world, and the pairing of language with visual images affects what is recalled about those images. For example, Loewenstein and Gentner (2005) found that children performed better in a mapping task when spatial relations were paired with spatial language at encoding. Relational language fosters the development of representational structures that facilitate mental processing (see also Hermer-Vazquez, Spelke, & Katsnelson, 1999). But language presented with a spatial scene can also lead to memory errors. For instance, Feist and Gentner (2007) showed that recognition memory for spatial scenes was shifted in the direction of the spatial relational language (spatial prepositions) presented with scenes at encoding. Although these studies show an effect of language on memory, it is not yet known *how* language affects memory. Here we focus on spatial demonstratives and possessives, and the possible effect these terms might have on memory for object location. In doing so, the continuous nature of object location memory errors allows us to contrast different possible mechanisms regarding how language affects memory for object location.

Demonstratives (*this, that)* have been shown to be associated with discrete zones of peri-personal and extra-personal (near and far) space (Diessel, 2006; Coventry et al., 2008). However, this distinction is flexible. Near space can be contracted or extended by weight or tool use (Longo & Lourenco, 2006), and the use of "*this"* is similarly extended when participants use a stick to point at objects (Coventry et al., 2008). Object knowledge also affects both perception and memory for object location. For example, Balcetis and Dunning (2010) showed that participants perceived desirable objects as being closer to themselves than less desirable objects. Previous research has also shown that several object properties, including ownership, visibility, and familiarity, influence the use of spatial demonstratives in English and memory for object location (Coventry et al., 2014).

In order to account for the influence of object knowledge on memory for object location (and by extrapolation, language), Coventry et al. (2014) proposed an *expectation model.* In this model, memory for object location is a function of the actual object location concatenated with where an object is expected to be (with a constant estimation error). For example, an object owned by the participant is expected to be nearer than an object owned by someone else. This results in the participant misremembering an object owned by someone else as further away than an object they owned at the same location. This expectation model also makes a prediction (tested below) regarding the direction of memory errors when demonstratives occur with objects at encoding. Specifically, it might be expected that "*this"* activates near space and "*that"* activates far space, and when conjoined with actual location, should lead to objects paired with "*that"* being (mis)remembered as being further away than they actually were (relative to objects paired with "*this*").

In contrast to the expectation model proposed by Coventry et al. (2014), there is a considerable body of work within an embodied cognition framework providing evidence for an alternative "*congruence account*" between language and space that makes different predictions from the expectation model. For example, it has been shown that participants respond more quickly to positive stimuli in a congruent high location than an incongruent low location, and vice versa for negative stimuli (e.g. Barsalou, 2008; Meier & Robinson, 2004; cf. Lynott & Coventry, 2014). Moreover, this congruence account has been extended to movement planning where movements were prepared based on language (Bonfiglioli et al., 2009). Participants were required to grip an object after listening to an instruction that indicated whether the object was near or far; RTs were significantly longer when language was incongruent with space compared to when language and space were congruent. In extrapolating this congruence account to memory, congruence in language and space would be predicted to enhance the accuracy of memory for location.

The goal of the present study was to test whether language affects memory for object location, and to unpack the mechanism involved. Specifically, we aimed to tease apart these two accounts by examining the effects of demonstratives and possessives on memory for object location. The first experiment tested whether spatial demonstratives affect memory for object location with contrasting predictions from the two different accounts of how language affects memory: congruence v. expectation. Experiment 2 tests whether similar effects occur for possessives (*my*, *your*) – terms which have also been associated with the peripersonal/ extrapersonal space distinction. Experiment 3 tests whether the effects found in Experiment 1 might be a result of a third variable – i.e. language affecting the amount of attention paid to an object at a given location.

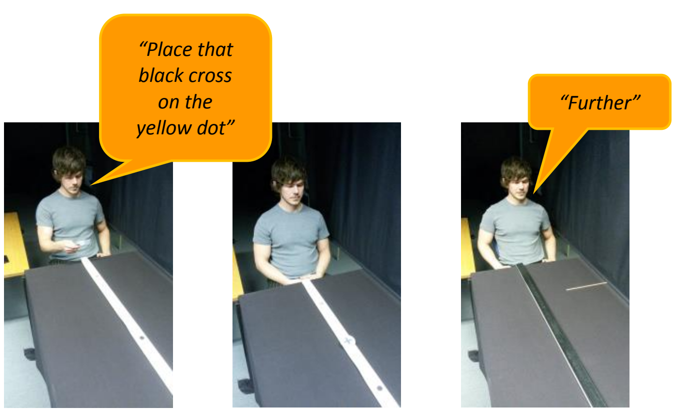

Figure 1. The participant reads out the instruction card, then memorizes the object location and finally instructs the experimenter verbally to match the indication stick to the object location.

Experiment 1

This experiment tested whether spatial demonstratives paired with an object at encoding affected memory for object location. The main goal was to test between the expectation and congruence models. Critically the expectation model predicts a <u>main effect</u> of demonstrative on object location memory and the congruence account predicts <u>an interaction</u> between demonstrative and distance, such that memory should be more accurate when language and object location are congruent.

Participants

In this study, 36 participants were tested. All were native English speakers receiving either course credit or payment for their participation. Stereoacuity was measured using the Randot Stereotest (Stereo Optical Inc. Chicago, USA) and participants who did not have a threshold of at least 40 arcseconds were excluded (N=2). Two additional participants were excluded because they produced more than 10% incorrect answers in the demonstrative memory task (see below). This left 32 participants for the analyses, 9 male and 23 female, with an age range of 18 – 31 years (M = 20.8, SD = 3.1).

Materials

Six distinguishable, different colored shapes on plastic discs (e.g. yellow triangle, blue heart), 6.5 cm in diameter, were placed on six different locations. The locations were spaced equidistantly along a midline from the participants' edge of a large conference table (L = 320cm, W = 90cm), starting at 25cm from the participant up to 150cm (Coventry, Valdés, Castillo, & Guijarro-Fuentes, 2008). The three dots that were closest to the participants were located within their peri-personal space, while the remaining three dots were within their extra-personal space (this was confirmed for each participant). The table was covered with a black cloth so that no spatial cues where present on the table.

Procedure and Design

Participants were asked to sit as close to the table as was comfortable, to ensure that all participants were approximately the same distance from the objects. Participants were told the experiment was testing memory for object location. On each trial, the participant read out an instruction card indicating the placement of an object on a location. The instructions all had the form: "Place DEMONSTRATIVE, OBJECT, on the COLOR dot" (e.g. Place this red triangle on the blue dot). Following the instruction participants closed their eyes while the experimenter placed the object as instructed. The participant was then given 10 seconds to memorize the object location, before the object and the dots were removed and the experimenter went behind a curtain to present an indication stick (to prevent the experimenter from cueing the participant). The participant verbally instructed the experimenter to match the near edge of the indication stick to the remembered near edge of the object location (thus ensuring that participants didn't move and kept the same distance from the table throughout the experiment). At the end of each trial, participants were required to verbally indicate the demonstrative used on the instruction card to ensure they had attended to the instructions (see Figure 1).

There were two demonstratives (*this, that)* and a neutral determiner (*the)*, six locations and six objects. Participants were presented with six practice trials, after which 54 experimental trials were conducted (consisting of 3 trials of every term on every location: 3×3×6). The indication stick was presented at a distance of 10cm (counterbalanced to be further or nearer) from the actual object location. To prevent the initial placement of the indication stick becoming a cue for object location there were three filler trials within the first 10 trials, in which the indication stick was presented at 20cm from the object location. Remembered distance was measured in millimeters. When a participant couldn't remember the demonstrative the trial was repeated at the end of the experiment (unless a participant couldn't remember >10%, in that case s/he was excluded). At the end of the experiment reaching distance was measured to check that every participant could reach only the first three dots but not the furthest three dots. The "memory game" cover meant that participants were not aware that we were interested in the differences between demonstratives (confirmed during debrief).

Results and Discussion

A 3 × 6 (demonstrative × location) ANOVA was performed on the difference (in millimeters) between the remembered position of the object and the actual position. There was a main effect of demonstrative $F(2,62) = 6.68$, $p < .01$, $\eta p^2 = .18$, showing a direct effect of language on memory for object location: follow up t-tests showed significant differences between locations accompanied by the demonstrative "*that*" ($M = 2.94$, $SD = .42$) compared to both the "*this*" ($M = 2.01$, $SD = .41$) and "*the"* ($M = 1.84$, $SD = .47$) conditions (both p*'s* < .05; see Figure 2[1]). There was a marginal effect of location $F(5,155) = 2.33$, $p = .08$, $\eta p^2 = .07$, revealing that memory for object location deteriorated with distance. More importantly, there was no significant interaction between demonstrative and location $F(10,310) = 1.4$, $p = .21$, $\eta p^2 = .04$. The results therefore support the expectation model rather than the congruence model; "*that"* leads to objects being misremembered as further away compared to "*this"*, irrespective of the congruence between the specific demonstrative and location.

Experiment 2

Some studies have shown that ownership influences memory for objects (Cunningham et al., 2008) and how people interact with objects (Constable, Kritikos, & Bayliss, 2011). Coventry et al. (2014), using the memory game, found that object ownership affected memory for object location and demonstrative choice. In Experiment 2, we investigated whether possessives (*my*, *your*) have the same influence on memory for object location as demonstratives, with the prediction that "*your"* objects would be associated with misremembered distances further away compared to "*my"* objects.

Participants

In this study 39 participants were tested. All participants were native English speakers receiving either course credit or

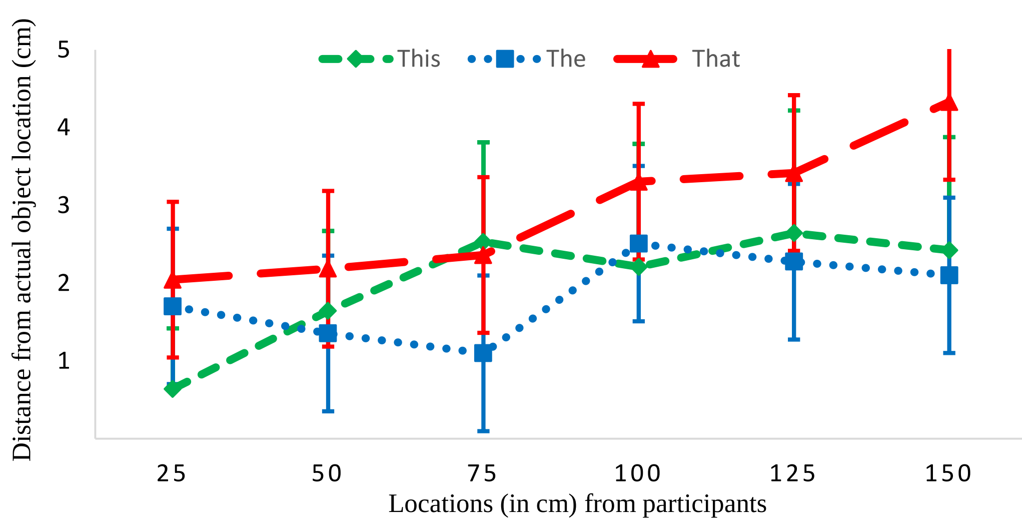

Figure 2. Results of Experiment 1, error bars are 95% confidence intervals.

[1] On the Y-axis, the absolute difference is presented (cm). A positive value means that objects were remembered as being further away than they were.

payment for their participation. Stereoacuity was measured as in Experiment 1. Two participants did not score a threshold of 40 arcseconds, two participants had more than 10% errors in the possessive memory task and one participant could not reach the second (50cm) dot. These participants were excluded from analysis, leaving 34 participants; 14 male and 20 female, with an age range of 18 – 44 years (M = 23.8, SD = 4.9).

Procedure and Design

The procedure was similar to Experiment 1, with the exception that the demonstratives were replaced with possessives (*my, your*).

Results and Discussion

A 3 × 6 (possessive: *my, your, the* × location) ANOVA was performed on the difference (in millimeters) between the actual position of an object and the memorized position. There was a main effect of possessive $F(2{,}66) = 8.25$, $p = .001$, $\eta_p^2 = .2$, showing that objects in the "*your*" condition (M = 1.89, SD = .43) were remembered significantly further away than objects in both the "*my*" condition (M = .81, SD = .34) and the "*the*" condition (M = 1.11, SD = .34), both $p < .05$; See Figure 3). A significant effect of location was found $F(5{,}165) = 3.47$, $p = .01$, $\eta_p^2 = .1$, showing that accuracy deteriorated as the objects were placed further away. Additionally there was an interaction between possessive and location $F(10{,}330) = 2.25$, $p = .03$, $\eta_p^2 = .06$. This effect indicates that the influence of language is different at different locations. To unpack this interaction three one-way ANOVAs were performed, to test location effects per term. These showed that there was only a reliable peri-personal/extra-personal effect in the "*your*" and "*the*" conditions ($p < .05$). This effect was absent in the "*my*" condition ($p > .05$; see Figure 3). This suggests that memory for possessed objects maybe particularly enhanced, overriding any effect of peri-personal versus extra-personal space. Note that this interaction effect is not as predicted by the congruency account (congruence between language and space should lead to more accuracy; this is not what was found).

Experiment 3

So far the results support the expectation account. However, there is a third, alternative account that we have thus far not considered. It could be the case that "*this*" causes participants to look at an object and object location for longer than "*that*", leading to better accuracy of recall. In this experiment, we used eye tracking to investigate this alternative hypothesis.

Participants

In this experiment, 19 participants were tested. All participants were native English speakers receiving either course credit or payment for their participation. Stereoacuity was measured as in Experiment 1; all participants had appropriate depth perception and their reach stretched between the 75cm and 100cm location. For three participants the eye-tracker could not be calibrated. These participants were excluded from analysis. This left 16 suitable participants for the analyses, 5 male and 11 female, with an age range of 18 – 22 years (M = 19.2, SD = 1.2).

Procedure and Design

The procedure was based on Experiments 1 and 2, but in this experiment, participants wore SMI eye-tracker glasses (30Hz binocular eye tracking glasses). For this reason, only 4 positions were used (the first location was too close for the eye-tracker and the furthest location was not useable because

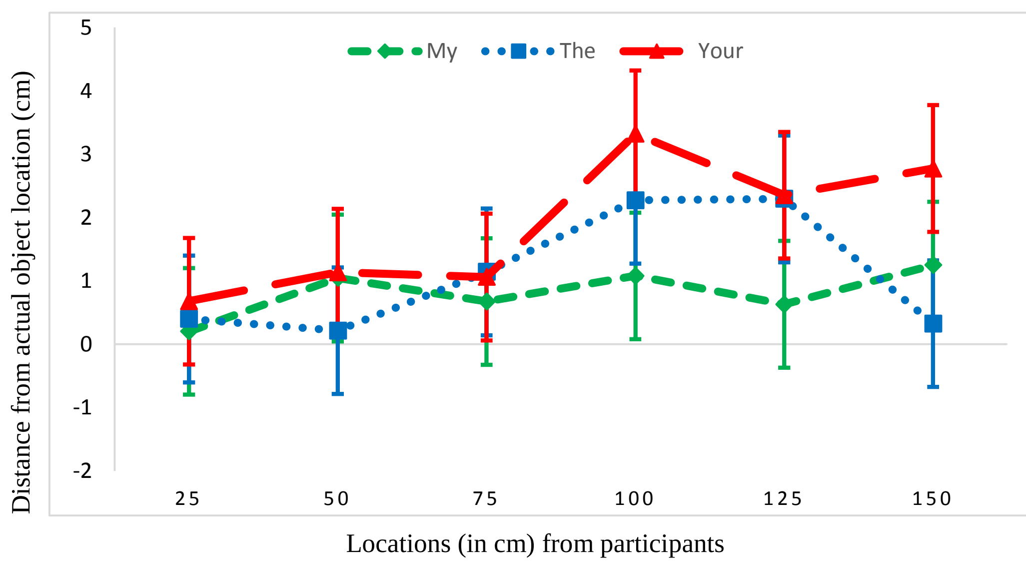

Figure 3. Results of Experiment 2, error-bars are 95% confidence intervals.

the area of interest was too distorted). Before the experiment started the glasses were calibrated using marks on the wall. After that, calibration was validated four times throughout the experiment by having participants look at the four different locations on the table. The eye-tracking data were coded using semantic gaze mapping[2]. As the visual angle from the participant to the object was different for every location, the standard error in calibration was slightly different per location. These differences in error had to be accounted for in the semantic gaze mapping. Therefore the coding was slightly less stringent for further locations compared to closer locations. For the furthest location any fixation within 6.5 cm of the object was marked as a fixation on the object. In the nearest location any fixation within half an object's size of the object was marked as a fixation on the object (see Figure 5). The gaze mapping data were used in a 3 × 4 (demonstrative × location) design, investigating the differences in total fixation time (ms) on the object.

Results and Discussion

The memory data was first analyzed in a 3 × 4 (demonstrative × location) ANOVA. A main effect of demonstrative was found $F(2,30) = 5.77$, $p < .01$, $\eta p^2 = .28$, in which recalled distances for object location in the "*this*" condition ($M = -.07$, $SD = .79$) were closer than in the "*that*" condition ($M = 1.77$, $SD = .68$) and the "*the*" condition ($M = 1.2$, $SD = .59$), both $p < .05$ (See Figure 4). The significant difference between the "*this*" and "*that*" condition is consistent with the results of Experiment 1. There was also a main effect of location $F(3,45) = 9.69$, $p = .001$, $\eta p^2 = .39$, in which participants' accuracy deteriorated as locations were further away. There was no interaction effect between demonstrative and location $F(6,90) = 1.61$, $p = .15$, $\eta p^2 = .1$, which means that the effect of language was the same across locations.

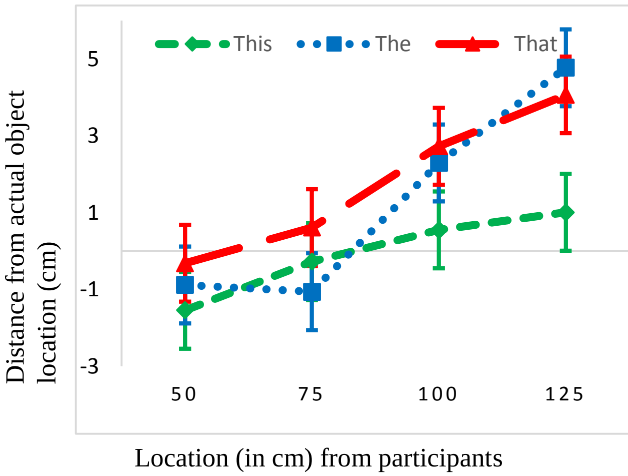

Figure 4. Results of Experiment 3. Error-bars are 95% confidence intervals.

[2] This involves the manual coding of video-based eye-tracking data, by which fixations are coded on a gaze map.

Regarding the gaze data; there was no significant difference in the amount of time objects were fixated as a result of language condition $F(2,30) = .13$, $p = .81$, $\eta p^2 = .009$, suggesting that language doesn't change the amount of time participants attended to a specific object/location. There was a location effect $F(3,45) = 4.66$, $p < .01$, $\eta p^2 = .24$, showing that participants fixated longer on locations further away, although the lack of measurement accuracy in the far locations may have influenced this effect. There was no interaction effect between demonstrative × location $F(6,90) = .62$, $p = .71$, $\eta p^2 = .04$, meaning that the influence of language was similar across different location conditions.

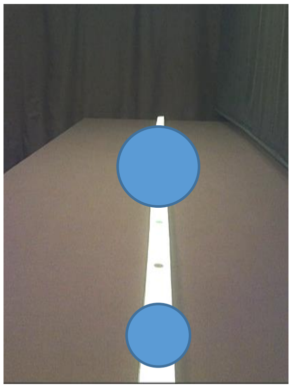

Figure 5. Object area in semantic gaze mapping

General Discussion

The results of all three experiments show that language affects memory for object location, with main effects of language in all cases. The use of both demonstratives (Experiment 1 and 3) and possessives (Experiment 2) affects memory for object location. These results are consistent with previous studies showing an influence of language on memory for spatial relations (Feist & Gentner, 2007; Loewenstein & Gentner, 2005), but our results show the first evidence of the influence of language on memory for object location. The results are also consistent with the manipulations of object knowledge on object location memory reported by Coventry et al. (2014).

In addition to the influence of language on object location memory, the experiments also revealed effects of location (the effect was marginal in Experiment 1), suggesting that participants' memory for object location deteriorates as the object is further away. These results again replicate effects of distance found in Coventry et al. (2014), and provide further evidence of the mapping between perceptual space and language and memory.

In these experiments, we have also been able to test between rival accounts of the influence of language on object location memory - the congruence account and the expectation account. We also considered a further possibility that language might affect the amount of time participants fixate an object. The difference between the expectation and congruence models is the prediction of an interaction effect in the latter, and the absence of an interaction effect in the former. The expectation account maintains that language elicits an expectation about an objects' location which is concatenated with actual object location, leading to the prediction that the language effect should be the same for objects in near space and far space. In contrast, the extended congruence account predicts that memory should be better for trials in which language is congruent with the situation, predicting an interaction effect between language and location; congruent trials (where *this/ that* are respectively combined with *near/ far* space) should be remembered better than incongruent trials (in which *this/ that* are respectively combined with *far/near* space). In Experiments 1 and 3 there was no interaction, supporting the expectation account. In Experiment 2 there was an interaction. However, this effect was driven by the absence of a location effect for the "*my"* condition and not by congruence/incongruence contrasts. Thus, as a whole, results of the current experiments all support the expectation account.

Experiment 3 tested the third possibility that different types of language might result in different amounts of attention being paid to objects/locations, with associated differences in memory performance. Put simply, the longer one spends looking at an object, the better one's memory for object location. The eye tracking data from this experiment revealed no differences in fixations on objects as a function of demonstrative, allowing us to discount this third possibility.

Overall the results support the expectation model. However, it remains to be established if this model operates at the level of encoding or at retrieval. One possibility is that "*this"*, for example, actually activates peripersonal space more when looking at an object than "*that"*, and therefore that the memory differences are a direct result of differences in peripersonal space activation during encoding. Such a view is consistent with recent models of perception (e.g. Bar, 2009) that incorporate top down predictions from memory as a mechanism during the act of perceiving. Alternatively, it is possible that the influence of language only occurs at retrieval, with remembered distances migrating in the direction of the remembered demonstrative/possessive. In order to test between these alternatives, it is possible to run neuroimaging studies to measure the degree of peripersonal space activation while viewing objects under different object knowledge and/or language conditions (see Coventry et al., 2014 for discussion). We are currently exploring this possibility.

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