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Impact of Scale on the Perception of Proximity as Represented in Latvian

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Abstract. Spatial proximity is not just a geometric attribute but is co-determined by factors of scale (visual scope or navigational scale), object features, and specific interactional patterns between objects, to mention just a few. We conducted three experiments to test the use of natural language proximity descriptors in Latvian (words representing different proximity operators in natural language). In a repeated-measures quasi-experiment (Study 1, n=25, adults), we used a rating task to evaluate a set of functional stimuli (photographs of everyday scenes) with independent variables of (a) scale (large- and small-scale space), distance (far or close), (b) object interaction, and (c) human presence in the scene. Next, we compared the observed regularities with the results from two repeated-measures quasi-experiments with geometric stimuli (two circles in different spatial relations to each other) - production task (Study 2.1., n=105, adults) and rating task (Study 2.2., n=92, adults). The experiment with functional stimuli shows differences in the use of spatial descriptors depending on scale, distance, and other tested factors. Small-scale configurations with a larger distance between objects allow a more variable, interchangeable and less context-dependent set of descriptors. The comparison of results from experiments on geometric and functional stimuli shows similar patterns in the use of spatial descriptors depending on the distance and indicates that abstract geometric relations are represented according to small-scale context.

Keywords: spatial relations, extensions of RCC, functional and geometric relations, small- and large-scale space, interaction between objects.

Introduction

We perceive relations between spatial objects in and of different scales ranging from visual scope (small-scale space) to larger navigable environments (large-scale space). In the first case, spatial visual geometry is crucial, whereas in the second case, the navigational patterns reflected in cognitive maps are important, and vision is only one source of information used for generating them (Denis, 2017).

Although scales constrain spatial relations and both visual scope and navigational scope spaces are interrelated, there are some discrepancies and commonalities between both scales.

Small-scale space contains movable forms and objects that involve recognition and categorization within the scope of the visual field, whereas large-scale space represents the shapes of large-scale, navigable surface layouts, enabling the distance estimation and perception of direction in 3D layouts (Lee and Spelke, 2010, Izard et al., 2011). A significant amount of experimental work focuses on small-scale spaces (e.g., Coventry and Garrod, 2004); at the same time, there is correlational and experimental work on navigable spaces (e.g., Golledge, 1999). Less known are the links, commonalities, and differences between both spaces.

Our study focuses on the way we perceive proximity relations on both scales. What are the differences and what are scale-independent features? What kind of spatial information is distorted once transformed from one scale of space to another? Are there geometric principles that are shared on both scales? These are the core questions underlying our study.

In both scales, we assume that spatial relations are perceived according to the principle that every object (Figure) is perceived by virtue of its reference object or neighbourhood (Ground) (Talmy, 2000). Scale-dependently we localise objects in Figure-Ground pairs and represent them in a natural language.

The main problem with the perception of proximity is that it cannot be reduced to a single distance function that operates in geometry. It also violates the principle of symmetry in that proximity from a Figure object (A) to the Ground object (B) is different than from B to A. Although distance impacts the perception of proximity, it is only one of the factors constraining the perception of proximity in a subtle way (Brennan and Martin, 2012). A solution might be to define relational operators as 'near' and 'close' in an algebraic framework (Frank, 1992), but even in these cases, context constrains the meaning of these operators.

We agree with Brennan and Martin (2012) that proximity is very much context dependent. Context dependence in the case of proximity is a multidimensional structure containing the object features (shape and size), presence of other objects (besides Figure and Ground), differences in scales, location, tasks that the users are supposed to do with the objects, reachability, recognisability, non-spatial features (such as aesthetic appreciation); finally, of course, also Euclidean distance and topological relations (e.g., connectivity) matter as well (Brennan and Martin, 2012, Gahegan, 1995).

Brennan and Martin (2012) argues that the distance between spatial borders of objects is not central in describing proximity. Instead, a richer concept of nearness (‘impact area’ in their terminology) has to be applied, including the object features, functionality, and environment. Distance in their concept of proximity (impact area) is just a modifying factor (besides other factors) instead of the proximity measure itself (2012, 94).

However, our approach is different from Brennan and Martin (2012) in that we use natural language-based spatial descriptors (that were experimentally tested before: Šķilters et al, 2020, Žilinskaitė-Šinkūnienė et al., 2019a, 2019b, 2020, and we do explicitly compare the perception of proximity in clear geometric and topological spatial relations with relations in everyday contexts (functional relations).

Considering the variety of impacting factors we assume that different proximity relations diverge from one another in several more or less predictable ways. Some proximity relations are constrained by (a) the connectedness of objects between Figure and Ground (cp. Zwarts, 2017), (b) the interaction between objects (Mani and Pustejovsky, 2012), (c) object type (animate or non-animate), (d) scale, (e) distance.

Besides different spatial relations, we are interested in the perception of spatial proximity in large-scale and small-scale settings. In particular, we are interested in the impact of (a) interaction between objects and (b) the type of object (animate (human) vs. non-animate). These were the independent variables in our study, along with the (c) scale (small- or large-scale) and (d) distance (far or close). We tested the expression of relational distance operators in natural language (Latvian). Our study was motivated by the diversity of proximity relations and their spatial descriptors that we use in everyday situations. The research questions we aim to answer and report in the Results section are: (1) what is the impact of the scale on the perception of proximity when stimuli from everyday scenes are varied depending on (a) distance (far or close), (b) interaction between objects and (c) presence of animate/non-animate object, and (2) how does the perception of proximity in functional stimuli differ from the abstract/geometric stimuli with clear geometric and topological spatial relations which we have studied previously (Šķilters et al., 2020, Žilinskaitė-Šinkūnienė et al., 2020).

Materials and methods

We have conducted a series of experiments to test the use of Latvian for describing spatial relations depending on topological, geometric, and functional factors (e.g., containment, support) (Šķilters et al., 2020, Žilinskaitė-Šinkūnienė et al., 2019a, 2019b, 2020). The research presented in this article is based on an online quasi-experiment (Study 1), with functional stimuli -photographs of everyday scenes representing relations between objects in small- or large-scale. Participants' task was to rate the acceptability of certain proximity descriptors (that are commonly used in Latvian). The descriptive words for proximity relations were primarily chosen according to Šķilters et al. (2020), in which participants had to describe the spatial relations of geometric objects (two circles) depending on various topological and geometrical features (including distance) in a production task (Study 2.1.). In addition, we compared ratings from Study 1 with the results of a similar study (Study 2.2.) with the rating task that we conducted to test the perception of proximity in the same geometrical stimuli with two circles.

In Study 2.1. (Šķilters et al., 2020, Žilinskaitė-Šinkūnienė et al., 2020) we explored what descriptors in Latvian are typically used for representing different spatial relations of geometric stimuli and what are the impacts of particular geometric features of spatial relations (including proximity) on the use of these descriptors. In addition, we conducted Study 2.2. where we tested the acceptability of several spatial descriptors for the same geometric stimuli in a rating task. Study 1 was developed to evaluate the interpretation

of functional stimuli and to examine whether the spatial descriptors are similarly used for both functional and geometric stimuli and, further, what are the impacts of scale, interaction of objects, and the presence of animate/non-animate objects.

Study 1. *Experiment with functional stimuli*

Participants

In total, 25 subjects participated in the study (gender-balanced, mean age 32 (SD=15), native Latvian speakers). All participants took part in the study voluntarily, and they were informed about the data arrangement policy, the opportunity to get acquainted with the results, and the possibility of withdrawing from the experiment at any time.

Stimuli and study design

We conducted an online in-group quasi-experiment in the form of a questionnaire combined with an experimental rating task using the QuestionPro platform. It had to be completed on a computer or tablet.

After a short introduction to the study procedure, participants received instructions on the experimental task and were presented with 48 scene stimuli in a randomized order. Their task was to rate five proximity descriptors in Latvian – 'at' (*pie*), 'next to' (*blakus*), 'beside' (*līdzās*), 'not far' (*netālu*), 'near' (*tuvumā*) - chosen according to the results by Šķilters et al. (2020). The participants had to rate the appropriateness of each of the five proximity descriptors for the given stimulus according to the following scale: 1- not appropriate, 2 - rather not appropriate, 3 - hard to tell, 4 - rather appropriate, 5 - appropriate.

The stimuli were photographs of everyday scenes specially created for the experiment (Figure 1 provides some examples, all stimuli are shown in Annex I). Each scene contained two objects, and participants were asked to rate the appropriateness of spatial descriptors by answering the question: "Evaluate the appropriateness of the proposed words to describe the location of Object 1 relative to Object 2!" (*Novērtējiet piedāvāto vārdu atbilstību, lai raksturotu Objekta 1 atrašanās vietu attiecībā pret Objektu 2!*).

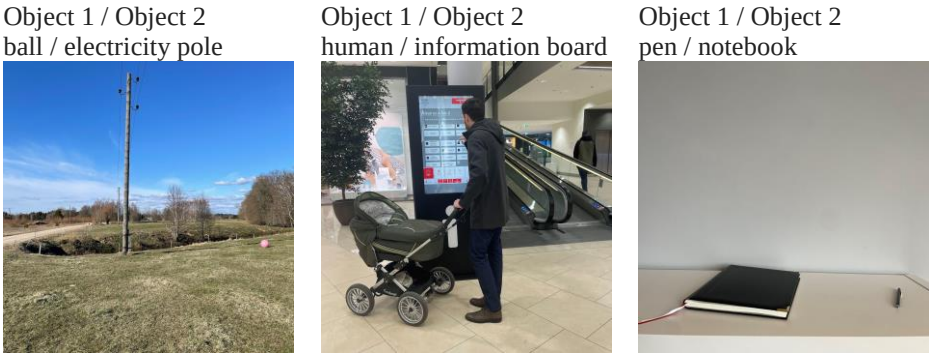


Figure 1. Examples of stimuli used in Study 1

According to the considerations described previously in the Introduction section, we chose four factors - (1) presence of the human, (2) size of scale (large or small), (3) interaction between the objects, and (4) close or far distance. The combination of factors resulted in 16 categories (Table 1), each containing three stimuli (Annex I).

Table 1. Factors tested in the Study 1 and categories of their combinations

Category	Distance between objects	Scale	Object interaction	Human presence
1	Close (~30cm)	Large	Interaction	Animate
2	Close (~30cm)			Non-animate
3	Close (~30cm)		No Interaction	Animate
4	Close (~30cm)			Non-animate
5	Close (~30cm)	Small	Interaction	Animate
6	Close (<2cm)		Interaction	Non-animate
7	Close (~30cm)		No Interaction	Animate
8	Close (<2cm)		No Interaction	Non-animate
9	Far (~5-6m)	Large	Interaction	Animate
10	Far (~5-6m)	Large	Interaction	Non-animate
11	Far (~5-6m)	Large	No Interaction	Animate
12	Far (~5-6m)	Large	No Interaction	Non-animate
13	Far(~1,5-2,5m)	Small	Interaction	Animate
14	Far (20-25cm)	Small	Interaction	Non-animate
15	Far(~1,5-2,5m)	Small	No Interaction	Animate
16	Far (20-25cm)	Small	No Interaction	Non-animate

Finally, participants had to answer a few demographic questions about their age, gender, mother tongue, and the field of education/occupation. The average time to complete the questionnaire was 24,2 minutes (SD=8,7 min).

Studies 2.1. and 2.2. *Experiments with geometrical stimuli*

We conducted two independent experiments (different participants participated in the experiments) - a production task (Šķilters et al., 2020, Žilinskaitė-Šinkūnienė et al., 2020) and a rating task - where we used geometric stimuli constructed according to the topological relations in Region Connection Calculus (RCC; Randell et al., 1992) and several geometric features (relative size, orientation, distance). Each stimulus depicts a

spatial scene containing two circles: the dark and the light one (Figure and Ground objects according to Talmy (2000)). The dark circle is the central element (Figure) that has to be located, whereas the light circle is the reference object (Ground) enabling the location of the dark one.

Study 2.1. Production task

The sample (n=105, gender-balanced, mean age 34 (SD=13), native Latvian speakers), stimuli, design, and procedure of the study are described in Šķilters et al. (2020) and Žilinskaitė-Šinkūnienė et al. (2020). The task in the study was to describe the location of the Figure object (dark circle) with respect to the reference (light circle) in a production task based on sentence completion (Carlson and Hill, 2007). Participants' task was to answer the question "Where is the dark circle?" (*Kur ir tumšais aplis?*), where the beginning of the response was already provided ("The dark circle…" (*Tumšais aplis…*)).

To answer the second research question of this article, we used only a subset of stimuli where geometric objects are to the left or to the right of each other (Table 2). These spatial relations correspond to the position of the objects in the functional stimuli.

Table 2. Geometric stimuli from Šķilters et al. (2020) selected for comparison in Study 2.1.

	DC, Far	**DC, Close**	**EC**
To the right	 1	 5	 9
To the left	 3	 7	 11
According RCC (Randell et al., 1992): DC - disconnectedness, EC- external connectedness Distance: Far, Close Orientation: To the right, To the left			

Study 2.2. Rating task

Participants

In total, 92 participants took part in the experiment (gender-balanced, mean age 33 (SD=15), native Latvian speakers). All participants took part in the study voluntarily, and they were informed about the data arrangement policy, the opportunity to get

acquainted with the results, and the possibility of withdrawing from the experiment at any time.

Stimuli and study design

We conducted an online quasi-experiment in the form of a questionnaire combined with an experimental rating task using the QuestionPro platform in which we used the same stimuli that were used in Study 2.1. For the comparisons with Study 1, we selected six stimuli shown in Table 2.

We constructed statements about stimuli describing the location of the dark circle with respect to the light one by using several spatial descriptors. The spatial descriptors tested were: 'next to' (*blakus*), 'near' (*tuvumā*), 'at' (*pie*), 'far' (*tālu*), 'to the left' (*pa kreisi*), 'to the right' (*pa labi*), 'behind' (*aiz*), and 'in front of' (*priekšā*) (Table 3). The statements were constructed as follows: "The dark circle is SPATIAL DESCRIPTOR the light circle" (e.g., The dark circle is NEAR the light circle (*Tumšais aplis ir TUVUMĀ gaišajam aplim*)). Participants were shown the stimuli in a randomized order along with a specific statement (containing a particular descriptor) and they had to rate it on a 5-point Likert scale - from 1-totally disagree to 5-totally agree. To reduce the number of rating tasks for each participant, we divided all combinations of the stimuli and the tested spatial descriptors (as contained in the statements to be rated) in three groups, each containing 40 stimuli, and participants were randomly assigned to one of the groups.

Table 3. Spatial descriptors tested in the studies

Spatial Descriptor in English (*Latvian*)	**Experiments that used the descriptor**
at (*pie*)	Study 1, Study 2.2.
next to (*blakus*)	Study 1, Study 2.2., Study 2.1.*
beside (*līdzās*)	Study 1
not far (*netālu*)	Study 1
near (*tuvumā*)	Study 1, Study 2.2.
far (*tālu*)	Study 2.2., Study 2.1.*
'to the left' (*pa kreisi*)	Study 2.2., Study 2.1.*
'to the right' (*pa labi*)	Study 2.2., Study 2.1.*
'behind' (*aiz*)	Study 2.2.
'in front of' (*priekšā*)	Study 2.2.
*only descriptors with a frequency greater than 10% were included in the analysis	

Finally, participants had to answer a few demographic questions about their age, gender, and field of education/occupation. The average time to fill in the questionnaire was 10,4 minutes (SD=5,4).

Results

The results are reported in answering to the study's research questions, which are set at the end of the Introduction section.

Research Question 1: what is the impact of scale on the perception of proximity when everyday situation stimuli are varied depending on (a) distance (far or close), (b) interaction between objects and (c) presence of an animate/non-animate object

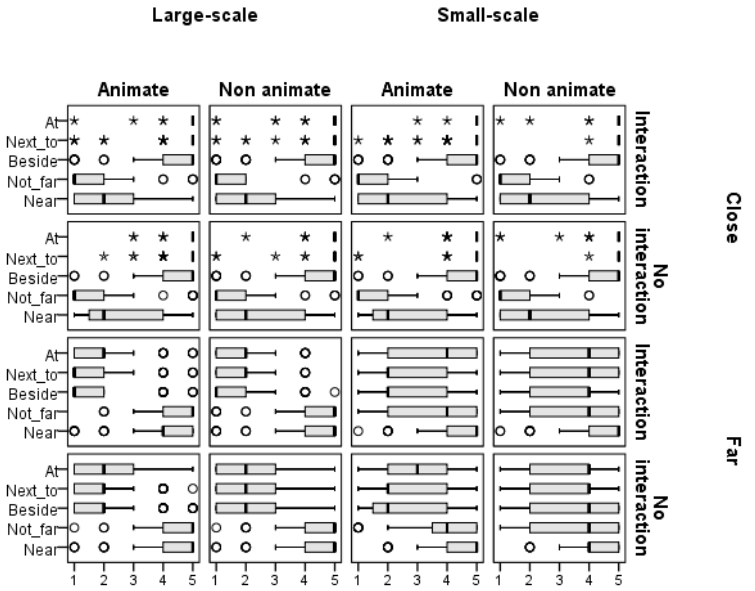
The summary results of the mean acceptability ratings of the spatial descriptors tested in Study 1 are summarized in Table 4. The differences and similar trends of the examined categories will be described in more detail.

Table 4. Mean acceptability ratings of the tested spatial descriptors in the experimental categories of Study 1

Category	Distance	Scale	Object interaction	Human presence	At *Pie*	Next to *Blakus*	Beside *Līdzās*	Not far *Netālu*	Near *Tuvumā*
1	Close	Large	Objects interact	Animate	4,9	4,5	4,2	1,5	2,2
2				Non-animate	4,8	4,7	4,2	1,6	2,3
3			Object does not interact	Animate	4,9	4,8	4,5	1,7	2,8
4				Non-animate	4,9	4,8	4,4	1,5	2,5
5		Small	Objects interact	Animate	5,0	4,5	4,1	1,4	2,4
6				Non-animate	4,9	5,0	4,3	1,5	2,4
7			Object does not interact	Animate	4,9	4,9	4,4	1,8	2,8
8				Non-animate	4,8	5,0	4,3	1,4	2,4
9	Far	Large	Objects interact	Animate	2,0	1,9	1,9	4,5	4,1
10				Non-animate	1,9	1,7	1,7	4,4	4,3
11			Object does not interact	Animate	2,2	2,0	2,2	4,6	4,3
12				Non-animate	2,2	2,3	2,2	4,5	4,2
13		Small	Objects interact	Animate	3,4	2,8	2,8	3,6	4,3
14				Non-animate	3,2	3,5	3,3	3,7	4,2
15			Object does not interact	Animate	3,0	2,8	2,8	4,0	4,3
16				Non-animate	3,5	3,3	3,1	3,5	4,1

Rating scale: 1- not appropriate, 2 - rather not appropriate, 3 - hard to tell, 4 - rather appropriate, 5 - appropriate.

The spatial descriptors appropriate for far distance (categories 9-16) are ‘not far’ (*netālu*) and ‘near’(*tuvumā*) with ratings from 3,5-4,6 points on average. These descriptors have been rated as inappropriate in close distance (categories 1-8), and ‘not far’ (*netālu*) has been rated as relatively less appropriate (1,5-1,8) than ‘near’ (*tuvumā*) (2,2-2,8). When comparing large- and small-scale ratings in far distance condition, the variation of ratings is generally smaller than those corresponding to close distance (Figure 2).



Rating scale: 1- not appropriate, 2 - rather not appropriate, 3 - hard to tell, 4 - rather appropriate, 5 - appropriate

Figure 2. Acceptability rating variations across categories examined in Study 1

When looking at the categories with human presence, in all cases of close distance, the appropriate descriptors are ‘at’ (*pie*), ‘next to’ (*blakus*), and ‘beside’ (*līdzās*) (4,1-5,0 points on average), with ‘at’ (*pie*) being the most appropriate in all conditions (4,9-5,0). In the case of small-scale and far distance, these descriptors are rated close to neutral (2,8-3,4) while in large-scale - as inappropriate on average (1,9-2,2). In the far distance conditions, the descriptors ‘not far’ (*netālu*) and ‘near’ (*tuvumā*) have been rated as appropriate in large-scale categories (4,1-4,5). In small-scale, the ratings of these descriptors are lower (3,6-4,3). Although the object interaction does not show a substantial effect, there is a tendency for the average ratings of appropriate descriptors in conditions without interaction to be slightly higher if compared to the same categories in conditions with interaction.

When considering the category with no human presence, the most appropriate descriptors for close distance were also ‘at’ (*pie*), ‘next to’ (*blakus*), and ‘beside’ (*līdzās*) (4,2-5,0), with ‘next to’ (*blakus*) being totally acceptable in the small-scale conditions (5,0 in average). These descriptors have been rated as almost appropriate also for far distance in small-scale conditions (3,1-3,5). However, in the large-scale conditions, they have not been found as appropriate (1,7-2,3) and the ratings are higher on average in conditions without object interaction. In the far distance conditions, the descriptors ‘not far’ (*netālu*) and ‘near’ (*tuvumā*) have been rated as appropriate in large-scale categories (4,2-4,5). In small-scale, the ratings of these descriptors are lower (3,5-4,2), which in this case is quite close to the ratings of ‘at’ (*pie*), ‘next to’ (*blakus*) and ‘beside’ (*līdzās*) with

average ratings 3,1-3,5. 'Not far' (*netālu*) and 'near' (*tuvumā*) have been rated as relatively not appropriate in close conditions (1,4-1,6 and 2,3-2,5 respectively).

To assess the effect of all factors together, the ordinal regression models were applied for each descriptor (Table 5). The results show that the acceptability rates of words are influenced by various factors. Relational distance (far or close) shows a significant effect for all tested words. Other tested factors show additional impacts on each word's appropriateness in different situations.

Table 5. Significant factors for acceptability of the proximity descriptors according to Study 1

	Distance	**Scale**	**Interaction**	**Human presence**	**Nagelkere R-square**
At *Pie*	Far (-)	Small (+)			,544
Next to *Blakus*	Far (-)	Small (+)	No interaction (+)	Non-animate (+)	,542
Beside *Līdzās*	Far (-)	Small (+)	No interaction (+)		,338
Not far *Netālu*	Far (+)	Small (-)		Non-animate (-)	,578
Near *Tuvumā*	Far (+)		No interaction (+)		,326
(+) increased appropriateness (-) decreased appropriateness					

Research Question 2: how does the proximity perception in functional stimuli (Study 1) differ from abstract geometric stimuli with clear geometric and topological spatial relations which we have studied previously (Study 2.1. (Šķilters et al., 2020, Žilinskaitė-Šinkūnienė et al., 2020) and Study 2.2.)

Next, we compare the results from Study 1 on functional stimuli with the relevant results from the studies on geometric stimuli (Studies 2.1. and 2.2.). The overview of these results is summarised in Table 6. Regarding the production task experiment (Study 2.1.), we included just the frequencies that are larger than 10%. If compared to the spatial descriptors tested in the experiment with functional stimuli (Study 1), two additional spatial description words - 'far'(*tālu*) and 'to the left'/'to the right' (*pa kreisi/pa labi*) are added. These words had also been tested in rating task for geometric stimuli (Study 2.2.). However, the rating task for geometric stimuli (Study 2.2.) did not include the descriptors 'beside' (*līdzās*) and 'not far'(*netālu*). These words were not typically used in the production task (Study 2.1.), and thus, they are not included in the summary table (Table 6). We compared the results to see if there are similar tendencies in the use of spatial descriptors comparing real-life situations and more abstract situations.

In the production task (Study 2.1.), the most frequent spatial descriptors represent horizontal orientation cues – to the left, to the right (74-86%). Other spatial description words are used less. In the case of disconnectedness, about 10% of the respondents have

used ‘far’ (*tālu*) for far distance and ‘next to’ (*blakus*) for close distance. 'Next to' (*blakus*) is more frequently used when objects are externally connected - 32% of the respondents used it in their descriptions. Although these results cannot be directly related to the results of the functional stimuli experiment (Study 1), we can observe a tendency to use ‘next to’ (*blakus*) in close distance settings (frequency 10/12%, acceptability 3,6/4,0 (Table 6)) which is also the case in Study 1 (acceptability rating 4,5-5,0 in close distance condition (Table 4)). Moreover, the ratings of appropriateness for ‘next to’ (*blakus*) are higher in the case of no object interaction (4,8-5,0).

Table 6. Spatial descriptors’ frequencies and average ratings of acceptability in Studies 2.1. and 2.2.

RCC, distance, orientation*	**DC, Far Left / Right**		**DC, Close Left / Right**		**EC Left / Right**	
2 sets of experiments	*Study 2.1.: Production task, frequency** *	*Study 2.2.: Rating task, average (scale 1-5)*	*Study 2.1.: Production task, frequency** *	*Study 2.2.: Rating task, average (scale 1-5)*	*Study 2.1.: Production task, frequency** *	*Study 2.2.: Rating task, average (scale 1-5)*
At *Pie*		1,7 / 2,2		**3,0 / 3,1**		**4,6 / 4,7**
Next to *Blakus*		2,6 / 2,7	12% / 10%	**4,0 / 3,6**	32% / 32%	**4,8 / 4,7**
Near *Tuvumā*		2,2 / 2,4		**3,5 / 4,4**		**4,3 / 4,0**
Far *Tālu*	12% / 10%	**3,1 / 3,4**		1,9 / 2,1		-
To the left / To the right *Pa kreisi/ Pa labi*	85% / 86%	**4,8 / 4,9**	85% / 83%	**4,5 / 4,5**	74% / 74%	**4,7 / 4,6**

According RCC (Randell et al., 1992): DC - disconnectedness, EC- external connectedness
Distance: Far, Close
Orientation: To the right, To the left
Rating scale: 1- totally disagree, 2 - disagree, **3 - hard to tell, 4 - agree, 5 - totally agree**
*The stimuli are shown in the Table 2
**Frequencies >10%

Comparing the production task (Study 2.1.) with the rating task (Study 2.2.), the results show a similar pattern - ratings of orientation descriptions are high on all tested categories. The higher ratings of ‘not far’ (*netālu*) in the case of disconnectedness with far distance (3,1/3,4) and ‘next to’ (*blakus*) in the case of close distance (4,0/3,6) are consistent with more frequent use of these words in the production task (10/12 %). In the

case of close distance, the ratings of ‘near’ (*tuvumā*) (3,5/4,4) are similarly acceptable to ‘next to’ (*blakus*). An interesting asymmetry can be observed here: when the dark circle is to the right, participants rated higher ‘near’ (*tuvumā*), but when it is to the left - participants rated higher ‘next to’(*blakus*). For close distance settings, ‘at’ (*pie*) is also rated as somewhat acceptable (3,0 / 3,1).

In the case of external connectedness, although the only frequently used spatial descriptor in the production task (Study 2.1.) was ‘next to’ (*blakus*) (32/.32 %) (besides the descriptors representing the orientation cues), in the rating task (Study 2.2.), the participants evaluated the acceptability as high for all tested spatial descriptors - ‘next to’ (*blakus*), ‘near’ (*tuvumā*), and ‘at’ (*pie*) (4,0-4,8).

The geometric stimuli rating task (Study 2.2.) can be compared more straightforwardly with the functional stimuli experiment (Study 1) because most of the tested spatial description words are the same in both experiments. For the functional stimuli (Study 1), the acceptability of ‘at’ (*pie*) in the far distance condition was rated as lower than in the close distance condition (2,0-3,5 and 4,8-5,0, respectively). This was also true for the rating of geometric stimuli (Study 2.2), where 'at' (*pie*) acceptability increases from 1,7/2,2 in far distance to 3,0/3,1 in close distance. In external connectedness conditions, 'at' (*pie*) is rated as highly appropriate (4,6/4,7), which corresponds to functional stimuli with object interaction in close distance (4,8-5,0) (Study 1). When ‘next to’ (*blakus*) is examined, the same pattern can be seen - in the case of functional stimuli (Study 1), it was rated as acceptable in close distance condition (4,5-5,0), and also in the case of geometrical stimuli (Study 2.2.), its acceptability increases as the distance becomes smaller (from 2,6/2,7 in far distance to 4,9/3,6 in close distance).

The use of ‘near’ (*tuvumā*), in turn, is somewhat contradicting. In the case of functional stimuli (Study 1), it was rated higher in far distance (4,1-4,3), which is not the case for geometric stimuli (Study 2.2.), where ‘near’ (*tuvumā*) is rated higher for close distance or external connectedness (3,5-4,4, in far distance - 2,2/2,4). This effect might be due to relative proportions of the circle size and distances between circles; however, additional studies would be needed to test this assumption.

Discussion and Conclusions

From the tested spatial descriptors, none are totally unacceptable when functional stimuli (Study 1) are considered (the lowest average rating is for ‘not far’ (*netālu*) in close settings (1,4-1,8)) (Table 4). However, for some conditions, particular spatial descriptors (‘next to’ (*blakus*), ‘at’ (*pie*)) are most acceptable (categories with an average rating of 5). The spatial descriptor ‘near’(*tuvumā*) does not have acceptability ratings less than 2,2 on average, and the highest rating is 4,3 indicating that it is not the best fit for locating objects, but it is also not critically inappropriate in any situation. We can assume that the default proximity operator is 'near' (*tuvumā*), allowing the widest scope of acceptable interpretations.

Almost in all tested conditions in Study 1, the distance between objects is a factor that shapes subgroups of spatial description words - ‘at’ (*pie*), ‘next to’ (*blakus*), and ‘beside’ (*līdzās*) for the close distance conditions and ‘not far’ (*netālu*) and ‘near' (*tuvumā*) for the far distance conditions (Table 4). However, in small-scale conditions with no human presence and far distance, the acceptability of all tested words is rated as

relatively acceptable (3,1-4,2; lowest rating for the animate condition is 2,8), with ‘near’ (*tuvumā*) being relatively more acceptable (4,1-4,3). That is, in general, on a small-scale with far distance, different spatial descriptors can be used more interchangeably and with a larger variability of use and still be considered appropriate. The average ratings for less appropriate descriptors in far distance conditions (‘at’ (*pie*), ‘next to’ (*blakus*), ‘beside’ (*līdzās*)) on large-scale space are lower than in small-scale (1,7-2,3 and 2,8-3,5, respectively), that is, they are somewhat more appropriate in small-scale than in large-scale.

The results indicate differences in the use of spatial descriptors depending also on object interaction and human presence, but these effects are somehow interfering with scale and distance. The results tentatively indicate that the default descriptor used in interactional configurations at close distance is 'at' (*pie*). Whereas the default proximity operator (allowing the largest variance of possible configurations) is 'near' (*tuvumā*). Unlike other tested spatial descriptors, ‘near’ (*tuvumā*) is not associated with significantly increased or decreased acceptability depending on scale, and unlike other most acceptable close proximity descriptors (‘next to’ (*blakus*) and ‘beside’ (*līdzās*)), ‘at’ (*pie*) is not significantly associated with no-interaction condition (Table 5). ‘Next to’ (*blakus*) is positively associated with non-animate conditions, but other factors also show significance (Table 5). Our results support and extend the findings by (Carlson-Radvansky et al., 1999), (Coventry and Garrod, 2004) in that we have used also large-scale object scenes and geometric configurations; in the same time, our results support at least some of the findings from these studies arguing that the interaction between objects and their functions impact the interpretation of spatial configurations.

The comparison of geometric and functional stimuli settings shows the similarities between (a) the word use in geometric stimuli (Study 2.1.) and (b) small-scale functional stimuli (Study 1) with no interaction and no human presence corresponding to the high acceptability rating in the close distance for ‘next to’ (*blakus*) (average rating 5,0). Another similar tendency - different spatial description words can be used more interchangeably and with less constraints (corresponding to the tested independent variables) and still be appropriate. This seems to indicate that small-scale configurations allow a more variable, interchangeable, and less context-dependant set of descriptors. The differences were in the use of ‘near’ (*tuvumā*), which was acceptable in case of geometric stimuli (Study 2.2.) in close distance (3,5/4,4), but relatively inappropriate in the case of functional stimuli (2,3-2,8) (Study 1).

Although there are some typical patterns of expressing proximity in spaces of different size, our results allow a general conclusion that spatial proximity is a very much context dependent concept with a large variety of differences impacted by scale, animacy, distance, and interaction. However, each of these factors has different and sometimes interfering impacts (Table 5). If the differences between the everyday functional object scenes and geometric configurations are examined, we might also argue that geometric factors are interrelated with functional ones. Our results indicate that once everyday object configurations are considered, geometric constraints are still applied (although to a different degree and with different modifications). This supports the view that geometric and functional relations are complementing instead of replacing one another (e.g., (Landau, and Munnich, 1998), (Zwarts, 2017)). We also agree with Brennan and Martin (2012) that proximity is context dependent and in our study were able to illustrate the impacts of some of the factors. We might also hypothesize that proximity (especially if further factors are included) is a dimensional structure (consisting of dimension of distance, interaction etc.) linking geometry and functional

knowledge in a more complex way by involving also the underlying causality and dynamics of the scene (Mani and Pustejovsky, 2012).

Finally, the number of participants in Study 1 is not large and can be considered a limitation, although it was sufficient for obtaining results about most typical proximity descriptors and their constraints.

Abbreviations

F – Figure object
G – Ground object
RCC – Region Connection Calculus

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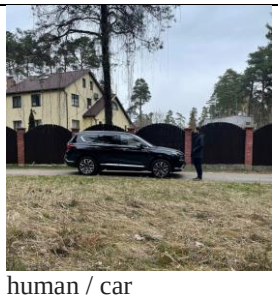
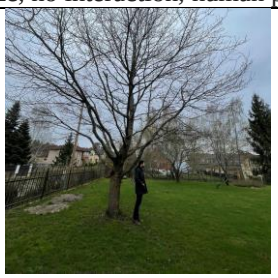
Annex I.

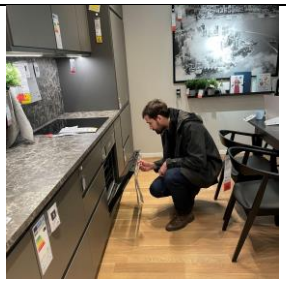
Stimuli used in the Study 1

Category 1 - **close, large-scale**, interaction, human presence		
 human / bus sign	 human / baby carriage	 human / car
Category 2 - **close, large-scale**, interaction, no human presence		
 garbage can / bus stop	 street lamp / road	 watering can / flower bed
Category 3 - **close, large-scale**, no interaction, human presence		
 human / water body	 human / tree	 human / road sign
Category 4 - **close, large-scale,** no interaction, no human presence		
 chair / water body	 chair / tree	 chair / grill

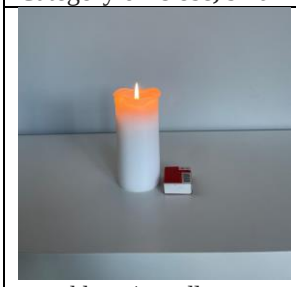
Category 5 - **close, small-scale,** interaction, human presence


human / information board


human / mirror


human / oven

Category 6 - **close, small-scale**, interaction, no human presence

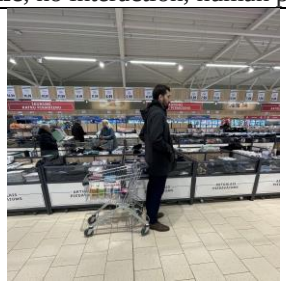

matchbox / candle


spoon / cup


pill / glass

Category 7 - **close, small-scale**, no interaction, human presence


human / toy train


human / shopping cart


human / refrigerator

Category 8 - **close, small-scale,** no interaction, no human presence


chocolate box / hammer


red bottle / cup


candy / bucket

Category 9 - **far, large-scale**, interaction, human presence


human / bus sign


human / baby carriage


human / sign ’For sale’

Category 10 - **far, large-scale**, interaction, no human presence


ball / basketball hoop


ball / football goal


car / road sign

Category 11 - **far, large-scale**, no interaction, human presence


human / basketball hoop


human / fence

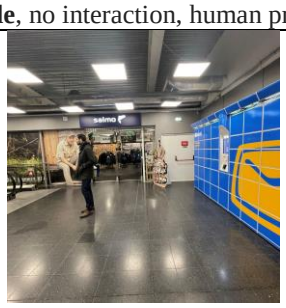
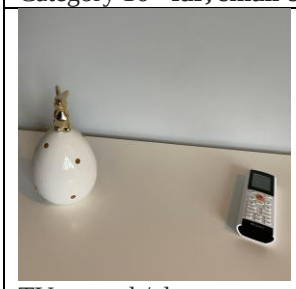
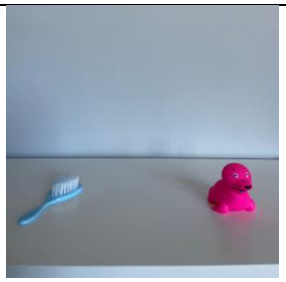

human / electricity pole

Category 12 - **far, large-scale**, no interaction, no human presence


basketball hoop / fence


birch (roadside) / read sign


ball / electricity pole

Category 13 - **far, small-scale**, interaction, human presence		
 human / mirror	 human / screen	 human / flowers
Category 14 - **far, small-scale**, interaction, no human presence		
 pen / notebook	 watering can / plant	 toothpaste / toothbrush
Category 15 - **far, small-scale**, no interaction, human presence		
 human / plant	 human / parcel station	 human / yellow armchair
Category 16 - **far, small-scale**, no interaction, no human presence		
 TV control / decor	 calculator / ball	 brush / toy

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