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A System for Analyzing Children and Caregivers' Language about Space in Structured and Unstructured Contexts

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I. Introduction

A. Purpose of Coding System

This coding system was developed for two research studies. The first study was designed to examine parents' use of spatial language as they engaged in puzzle play with their young children. The second study was designed to examine patterns and growth in children's spatial language production, as well as its association with caregiver spatial language production and children's performance on various spatial tasks. In addition, we are currently in the process of applying this coding system to two additional studies. One of these studies is concerned with parents' speech to their children in the context of other structured activities (e.g., book reading and construction activities). The other study examines preschool teachers' use of spatial language.

Two beliefs about spatial language motivated these studies. The first belief concerns spatial language input. We would argue, as have others, that hearing spatial language can "foster the learning and retention [of spatial concepts by]… inviting children to store the information and its label" (Gentner, 2003, p. 207-208). The second belief concerns children's spatial language production; we assume that the spatial language children produce is a reflection of their understanding of spatial concepts. For example, a child whose vocabulary includes words such as "long", "square", and "between" is likely to have a greater understanding of the concepts these words represent than a child who does not possess this vocabulary.

In all of our investigations of spatial language we were interested in determining the specific domains of spatial phenomena that parents and children talk about. Therefore, the following document is divided into the eight domains/ categories of spatial phenomena that we have identified children and parents talk about. Within each domain, we have identified sub-domains/ concepts. At the moment, we do not have coders code whether language is used to refer to a given concepts. Rather, coders use these concepts as a guide for deciding the language that falls within the broader eight domains. However, if a coder comes across a usage that does not fall into one of these concepts than that usage is not coded as "spatial."

B. How to Use the Coding System

We have developed two systems for using this coding system: 1) an utterance-level analysis and 2) a word-type-level analysis. The first system has coders review every utterance spoken and determine a) whether or not it is spatial and b) the spatial domain talked about. (In rare cases, the coder must also look at the DVD to determine the referent.) A given utterance can be coded as referring to *multiple* spatial domains. This system was/ is being used in the studies of specific contexts (e.g., puzzle play, book-reading, construction activities) and the preschool teacher study.

The second system is being used for the studies of children and parents' overall naturalistic spatial language. These studies involve too large datasets to analyze using the first system. Instead, coders first review a list, generated by a computer programmer, of all word types spoken by parents/ children. The coder examines these word lists for any word types that might potentially have a spatial meaning. For those words "red-flagged" as potentially spatial, the coder next goes to the transcripts and determines a) if the word was used in a spatial context and b) the spatial domain talked about. (In rare cases, the coder must also look at the DVD to determine the referent.) A given *usage* can only be coded as referring to one spatial domain although some *words* could be used to refer to multiple spatial domains.

Clearly, the datasets coded according to the first system could also be coded according to the second system. Similarly, the word-types system could be used to identify potentially spatial *utterances* and then the first coding system could be applied. However, we have yet to do this. Nonetheless, the two coding systems both yield measures of the frequency with which individuals talk about different spatial domains.

In sum, the utterance-level analysis requires the coder to make two decisions, while the word-type-level analysis requires the coder to make three decisions:

Utterance-level analysis (ULA):
> *Decision #1*: Is the utterance spatial?
> *Decision #2*: If so, which spatial domain(s)?

Word-type-level analysis (WTLA):
> *Decision #1*: Is the word type potentially spatial?
> *Decision #2*: If so, in the transcript is the word type used spatially?
> *Decision #3*: If so, which spatial domain?

Decision #1 for the ULA and decision #2 for the WTLA require the coder to differentiate between spatial and non-spatial usages. In section II, we describe common non-spatial usages. In the subsequent sections, we provide a definition of each spatial domain, the concepts that it includes, as well as *example* word types (and additional forms of these word types) for each concepts. It should be stressed that these word types are only examples; the list of words included in this document is not comprehensive. Coders use these word types as a guide for decision #1 in the WTLA, as well as decision #2 in the ULA and decision #3 in the WTLA.

C. General Notes

The *puzzle study* did not code as spatial some of the 8 domains of spatial language, as well as some of the sub-domains/ concepts. Our goal in this study was to examine the relation between spatial language and children's ability to mentally transform two-dimensional images. We therefore only included in our analysis spatial language that we predicted would be relevant to this skill. In other words,

while there are many aspects of speech that could be considered "spatial", we believe some of this language is not germane to the task of having to imagine object movements in the picture-plane (e.g., language concerning support like "off" and "on", spatial deictic terms such as "here" and "there"). In addition, we only included usages of listed terms that concerned the construction of puzzles (e.g., we did not include "the cat ran *under* the chair"). We have highlighted in gray those domains and sub-domains that were included in this analysis.

For the *word-types* analysis, a word type could contain one or more words. For example, "next to" is counted as one word type.

Our process for determining the *reliability* of the coding system is to have a second coder independently code 20% of the data. We calculate reliability for each of the decisions in the coding system, as well as the total reliability (i.e., how much do the two sets of final codes correspond?). Our reliability criterion is 80% intercoder agreement for both the ULA and the WTLA.

II. Common Non-Spatial Usages

The following contextual and semantic uses of spatial language were not included in our analysis. To determine whether a given word type or utterance fell into one of these categories, we examined all relevant information: the syntax of the utterance, the surrounding environmental context (both from the transcript and when necessary the video recording), and the proceeding and subsequent utterance(s). In most cases, however, it was only necessary to examine the target utterance.

A. Non-Spatial Usages for All Word Types

1) **Homonyms**: We encountered this usage most when conducting the WTLA. These are instances where a word type, identified as potentially being used to convey spatial meaning, was in fact used as a non-spatial homonym. Also included here are diminutives/ endearments such as "you are a *little* angel" or "are you my *big* guy?"
    Examples:
    - "I *left* my hat in the car."
    - "That is the *right* answer."
    - "It's your *turn*."
    - "*Close* the door."
    - "Let's play our *little* game."

2) **Metaphors/ Abstract Phenomena**: Words that are often used to convey spatial meaning can also be used metaphorically, to connote relations, dimensions, and movement that do not have a tangible existence in real 2D or 3D space (e.g., degree of an abstract continuum such as time). We do not count any of these usages as being spatial.
    Examples:
    - "You have a *big* heart."
    - "This is a *little* problem."
    - "That took a *long* time."
    - "The *back* of my mind."
    - "He is *out of* his mind."

3) **Spatially Ambiguous**: Certain usages of spatial language convey meanings that are equally likely to refer to phenomena in real 2D or 3D space as they are to refer to abstract phenomena (e.g., time), or both. For these cases, the ambiguity does not lie in being unaware of the speaker's intentions; rather, the ambiguity is an inherent part of English semantics.
    Examples:
    - "It will only be a *short* walk."
    - "That was a *big* meal."
    - "He's your *little* brother."
    - "I'm *full* because I just ate lunch"

4) **Nominatives**: Spatial word types can be used as part of a name. With these usages, it is unclear whether the speaker and/or listener encodes the spatial meaning of the target word, or encodes it as part of a name (e.g., *Big* Bird is equivalent to John Smith). Similarly, a) spatial word types that are also names for body parts, b) prepositions compounded with verbs, adverbs or conjunctions, c) *inside* & *outside* used instead of *indoors*/ *outdoors* fell under this category because of the uncertainty concerning how individuals encode their meaning.
   Examples:
   - "*Big* Bird"
   - "*Little* Drummer Boy"
   - "My *back* hurts"
   - "Sit on your *bottom/behind*"
   - "Don't go *up*stairs."

5) **Other**: We have debated the following common usages and have determined them to be non-spatial because we believe it is questionable/ ambiguous whether an individual encodes their meaning as referring to spatial phenomena.
   Examples:
   - "*Turn* on the light/ television."
   - "Let's play/eat *together*."
   - "He was *on/ in* the bus."
   - "I hate the boy *in* the book."
   - "Go *away*."
   - "Look *into/ at* my eyes." (The reason these references are non-spatial is because they are used with a non-motion verb.)
   - "I want to eat it *with* milk."

A. Non-Spatial Usages for Prepositions Only

The following categories of non-spatial usages are encountered only when coding words that are can function as prepositions conveying meanings about location and direction (e.g., in, on, up). We refer to these words as "prepositions" but they can function as other parts of speech. Further, even when these words are used as prepositions, they can convey non-spatial meanings.

6) **Verb particles**: In a number of instances, prepositions do not convey spatial meaning but instead function as part of a phrasal verb that is an idiomatic expression. That is, the preposition is paired with a verb to form a complete semantic unit. For example, in "look *up* the word in the dictionary", "look up" cannot be broken down into an independent verb and preposition; rather, the two words functions as a verb that has a different meaning from the verb and preposition used on its own (look + up = investigate). See Appendix A for a list of many (but not all) English phrasal verbs.
   Examples:
   - "I ran *into* a friend."

- "Turn *on*/ *off* the light."
- "Get *over* it."
- "Oh, come *on*!"
- "Fold *up* the letter."
- "Let's get *out of doors* today."
- "Did you go *into hiding*?"
- "Did he get *on board*?"
- "Do it *by yourself*."

7) **Non-spatial Prepositional Relations**: Prepositions are used to convey relationships between an object and the rest of the sentence. Sometimes these relationships concern location and direction: the answer to "the *where* question." Prepositions can also convey relations of time, method, manner, conveyance, agent/ subject, state, condition, reason, purposes, or possession.
   Examples:
   - "Daddy said he'd meet us *between* 5 and 6 o'clock."
   - "We have to return the movie *by* Friday."
   - "I am leaving *in* five minutes."
   - "Your doctor's appointment is *on* Tuesday."
   - "Eat *with* your fork."
   - "Play *with* me."
   - "He is *in* one of those moods."
   - "He went *by* train."
   - "I'll wear it *with* pride."
   - "I'm bad *at* math."
   - "The book is *on/ about* colors."
   - "I was hit *by* a ball."
   - "I came *on* foot."
   - "Talk *on* the phone."
   - "I moved it *to* make some more room."
   - "The book was written *by* Dr. Seuss."
   - "Get the truck *from* your favorite toy store."

III. One Page Summary of Spatial Categories

A. *Spatial Dimensions*: Words that describe the size of objects, people, and spaces.

B. *Shapes*: Words that describe the standard or universally recognized form of enclosed two- and three-dimensional objects and spaces.

C. *Locations and Directions*: Words that describe the relative position of objects, people, and points in space.

D. *Orientations and Transformations*: Words that describe the relative orientation or transformation of objects and people in space.

E. *Continuous Amount*: Words that describe amount (including relative amount) of continuous quantities (including extent of an object, space, liquid, etc.).

F. *Deictics*: Words that are place deictics/ pro-forms (i.e., these words rely on context to understand their referent).

G. *Spatial Features and Properties*: Words that describe the features and properties of 2D and 3D objects, spaces, people, and the properties of their features.

H. *Pattern*: Words that <u>indicate</u> a person may be talking about a spatial pattern (e.g., big, little, big, little, etc. or small circle, bigger circle, even bigger circle, etc.).

A. Spatial Dimensions

Definition: Words that describe the size of objects, people, and spaces.

Parameters/Notes: We do not include references to weight or density because they refer to dimensions that do not have a tangible presence in the 2D or 3D world. References to standard measurement units, although closely related to this category, were included under Category E (Continuous Amount). Entire category was included in puzzle analysis.

Concept *Terms that refer to:*	Words	Additional forms
"unconstrained" spatial dimensions (i.e., these words can refer to length, height, or both dimensions)	Big Little Small Large Tiny Enormous Huge Gigantic Teeny Itsy-bitsy Itty-bitty	-er, -est -er, -est -er, -est -er, -est -er, -est
only horizontal or vertical extent	Long Short	-er, -est
only vertical extent	Tall	-er, -est
only horizontal extent	Wide Narrow Thick Thin Skinny Fat	-er, -est -er, -est -er, -est -er, -est -er, -est -er, -est
only vertical or horizontal extent of a 3D object/ space	Deep Shallow	-er, -est -er, -est
only internal extent of an, at least partially, enclosed 3D object/ space	Full Empty	-er, -est -er, -est
the superordinates of the above	Size Length Height Width Depth Volume Capacity Area (as in of a square) Measure	-s -s -s -s -s -s -s -s -s, -ment(s)

B. Shapes

Definition: Words that describe the standard or universally recognized form of enclosed two- and three-dimensional objects and spaces.

Parameters/Notes: This list does not include words that describe portions of shapes (e.g., lines, arcs, etc.) – those are included in Category G (Spatial Features and Properties). We also did not include words such as "heart" and "star" because it is unclear whether individuals encode these words as referring to the shape of the object or its identity. In addition, we do not include usages such as "ice cream *cone*" & "ice *cube*" because they do not always have the standard form of these shapes (e.g., the cone portion of an ice cream cone can be conical or the shape of a cylinder, an ice cube is still an ice cube even if it is only part of a cube or if it is distorted as a result of melting). Entire category was included in puzzle analysis.

Concept *Terms that refer to:*	Words	Additional forms
2D enclosed shapes that do not have any sides or angles or do not have all straight sides	Circle	-s
	Oval	-s
	Ellipse	-s
	Semicircle	-s
2D shapes with at least 3 straight sides and angles	Triangle	-s
	Square	-s
	Rectangle	-s
	Diamond	-s
	Pentagon	-s
	Hexagon	-s
	Octagon	-s
	Parallelogram	-s
	Quadrilateral	-s
	Rhombus	-s
	Polygon	
3D shapes	Sphere	-s
	Globe	-s
	Cone	-s
	Cylinder	-s
	Pyramid	-s
	Cube	-s
	Rectangular Prism	-s
the superordinate of above	Shape	-s

C. Location and Direction

Definition: Words that describe the relative position of objects, people, and points in space.

Parameters/Notes: This is our largest category and includes terms that function in numerous parts of speech. The reader should refer to the parameters section of Category G (Spatial Features and Properties) as some terms are included in both that category and here. Only highlighted concepts were included in puzzle analysis.

Concept *Terms that refer to a position* *(or movement towards a position)* *that is:*	Words	Additional forms
the noun that follows the term (in the case of "from" the reference is to movement *away* from the noun)	At To From	-ward(s)
resting/ not resting along a surface (including an "invisible" surface that is a boundary of a space such as in "on the side" and "on the bottom")	On Off	-to, up-
within or outside of the boundaries of an area or confines of a volume	In Out (of)	-to, -side, with- -side
along a vertical axis (in the case of "top" and "bottom" this includes the intrinsic vertical axis of the object/ person)	Under Beneath Below Over Above Up Down (On) top Bottom High Low Column Vertical	-neath -er, -ward -er, -ward -er, -est -er, -est -s -ly
along a horizontal axis (in the case of "front", "back", "left", and "right" this includes the intrinsic horizontal axis of the object/ person)	Left Right (In) front (In) back Ahead Behind Sideways Row Horizontal	-ward -ward -s -ly

Concept *Terms that refer to a position* *(or movement towards a position)* *that is:*	Words	Additional forms
proximal/ distal to another point	By Near Close Next to With Beside Far Away Beyond Further Past Against Together Separate Join Apart	 -by, -er, -est -er, -est -er, -est -d -d
defined with respect to the location of at least two other object/ people/ points	Between Among	
an equal distance from the extremities of something	Middle Center	
in the broad vicinity of another point	About Around Throughout	
defined with respect to the length of an object/ person/ point	Along Lengthwise	
in a cardinal direction	North South East West	-ern -ern -ern -ern
from one side to another side of (or circumvents) another object/ person/ point	Around Through	
on the (other) side of another object/ person/ point	Across Over Opposite Aside Reverse	

Concept *Terms that refer to a position* *(or movement towards a position)* *that is:*	Words	Additional forms
defined by the direction that an object/person/point/plane is oriented	Around Reverse Back *(verb)* Backward Forward Parallel Perpendicular Diagonal Down (as in "down the street") Up (as in "up the street")	-d
the superordinates of above	Location Position Direction Route Path Head Place Distance	-s -s -s -s -s -s, -d, -ing -s -s

D. Orientation and Transformation

Definition: Words that describe the relative orientation or transformation of objects and people in space.

Parameters/Notes: Theoretically, many verbs would fall into this category (i.e., any verb that encodes the direction or location of movement). A common distinction in the literature is between manner verbs and path verbs (with path verbs often thought of as not requiring a preposition to describe the direction of motion). However, we have found that there is much debate, both in the literature and amongst ourselves, about what verbs can be considered path verbs and can be considered to carry spatial meaning. For example, some define "turn" as a path verb (it describes movement around an axis), others a manner verb (a preposition such as "around" or "over" clarifies which axis). "Swim" is clearly a manner verb in the path vs. manner distinction, yet it implies that the person swimming is in, not outside, of water. "Jump" and "bounce" encode manner and path. At the moment, because we have not reached consensus on which verbs are and are not spatial, we do not code them in our system. We explicitly state this as a limitation in all of our papers on our current work; we hope in the future to rectify this limitation. The transformation verbs listed below are the *only* ones we currently count in our coding system because, when creating the coding system, we were particularly interested in language relevant to object transformations around an axis. Entire category was included in puzzle analysis.

Concept *Terms that refer to:*	Words	Additional forms
the orientation of an object or person	Upside down Right side up Upright	
the superordinate of the above	Orientation	-s
a transformation around an axis	Turn Flip Rotate	-s, -ed, -ing -s, -ed, -ing -s, -ed, -ing
the superordinate of the above	Rotation	-s

E. Continuous Amount

Definition: Words that describe amount (including relative amount) of continuous quantities (including extent of an object, space, liquid, etc.).

Parameters/Notes: We did not include in our analyses of these terms references to discrete quantities (e.g., "some cookies"). We also do not include continuous quantities that refer to non-spatial dimensions (e.g., time, temperature, weight, money, etc.). Only highlighted concepts (pertinent to part/whole relations) were included in puzzle analysis.

Concept *Terms that refer to:*	Words	Additional forms
the entire amount of a continuous object or space	Whole All	-s
an inexact part of a continuous object or space	Part Piece Section Bit Segment Portion Fragment Fraction Some A lot A little Much Enough	-s -s -s -s -s -s -s -s
an exact part of a continuous object or space	Half Third Quarter Fifth Sixth Seventh Eight Ninth Tenth *Etc.*	-s -s -s -s -s -s -s -s -s
the absence of a continuous amount	None	
a comparison between continuous amounts	More Less Same Equal	

Concept *Terms that refer to:*	**Words**	**Additional forms**
standard spatial measurement units	Inch Foot Mile Centimeter Meter *Etc.*	-s -s -s -s -s
the superordinates of above	Amount Room Space Area (as in "space")	-s -s -s -s

F. Deictics

Definition: Words that are place deictics/ pro-forms (i.e., these words rely on context to understand their referent).

Parameters/Notes: Entire category was NOT included in puzzle analysis.

Concept *Terms that refer to:*	Words	Additional forms
the location of the speaker	Here	
a location other than that of the speaker	There	
a request for identification of a location	Where	
no, any, some, or all location(s)	Anywhere Somewhere Nowhere Everywhere Wherever	

G. Spatial Features and Properties

Definition: Words that describe the features and properties of 2D and 3D objects, spaces, people, and the properties of their features.

Parameters/Notes: Some of the words on this list are also on the list of terms pertaining to category C (Location and Direction). The distinction is that they are coded as being a member of the current category if they are referring solely to the features/ properties of a single shape or space (e.g., "parallel sides of a square"). If they are used to refer to the relation between two or more objects, spaces, or people they would be coded as a member of Category C (e.g., "the river runs parallel to our house"). In addition, it should be noted that terms such as top and bottom, although often used to refer to a feature of a shape (e.g., "the top of the box"), are coded under category C. Entire category was included in puzzle analysis.

Concept *Terms that refer to:*	Words	Additional forms
the flat surface of an object	Side	-s, -d
	Edge	-s, -d
	Border	-s, -d
	Line	-s
curvature of an object or the curved portion of an object	Round	-er, -est, -ed
	Curve	-s, -ed, -y
	Bump	-s, -ed, -y
	Bent/d	-d, -s, -ed, -y
	Wave	-s, -y
	Lump	-s, -y
	Arc	-s
	Sector	-s
lack of curvature of an object	Straight	-er, -est
	Flat	-er, -est
the place where two or more sides of an object meet	Angle	-s
	Corner	-s
	Point	-s, -ed, -y
a surface of a 3D object	Plane	-s
	Surface	-s
	Face	-s
having the form of standards shapes, or in the case of "shaped" used with an object noun to describe the outline of a 2D or 3D shape or space (e.g., "heart-shaped")	Circular	
	Rectangular	
	Triangular	
	Conical	
	Spheric	-al
	Elliptical	
	Cylindric	-al
	Shaped	

Concept *Terms that refer to:*	Words	Additional forms
the orientation of an element of a 2D or 3D shape or space	Horizontal Vertical Diagonal Axis	 -s -s
the relation between elements (e.g., sides, halves) of 2D or 3D shapes or spaces	Parallel Perpendicular Symmetry	 -ic(al)

H. Pattern

Definition: Words that <u>indicate</u> a person may be talking about a spatial pattern (e.g., big, little, big, little, etc. or small circle, bigger circle, even bigger circle, etc.).

Parameters/Notes: As opposed to most of our other categories, there is not a clear-cut list of words that pertain to patterns. The following words help identify where pattern discussion **may** occur. However, we have found that if a child, parent, or early childhood teacher is talking about patterns, they often use one of these words. We do not include here numeric patterns (e.g., 1, 3, 1, 3) or patterns of non-spatial dimensions (e.g., light gray, gray, darker gray, etc.) Entire category was NOT included in puzzle analysis.

Concept *Terms that refer to:*	Words	Additional forms
a spatial array having a consistent regularity or rule to its organization	Pattern Design Sequence Order	-s -s -s -s
the relative location of an element in a patterned spatial array	Next First Last Before After	
the type of organization of a patterned spatial array	Repeat (repetition) Increase Decrease	-s, -ed, -ing -s, -ed, -ing -s, -ed, -ing
the superordinates of above	Pattern Design Sequence Order	-s -s -s -s