Topological spatial representation across and within languages

IN and ON in Mandarin Chinese and English

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This paper examines the commonalities and variations between and within groups of English and Chinese (Mandarin) speakers in using terms to refer to the topological spatial concepts of containment (expressed by *in* and related terms in English) and support (expressed by *on* and related terms in English). In addition to crosslinguistic similarities, systematic differences in the use of linguistic expressions by Mandarin and English speakers for these topological spatial relationships were found, as well as systematic individual differences within each language group. Together, these findings point to potential underlying differences in how speakers of English and Mandarin conceptualize these two topological spatial categories.

Keywords: spatial prepositions, crosslinguistic differences, Mandarin, English

There has been a lot of interest in recent years in how different languages afford speakers the possibility of focusing attention on the spatial relationships between objects in their environment (see, for example, Ameka & Levinson, 2007; Bloom, Peterson, Nadel, & Garrett, 1996; Levinson, 2003; Levinson & Wilkins, 2006). One reason for this interest is the following puzzle: the capacity to experience and think about space is universal yet cross-language comparisons reveal an unexpectedly large diversity in the way people speak about spatial relationships (Kleiner, 2004).

The wide crosslinguistic diversity can even be seen in the categorization of what would seem to be very basic topological relationships, including IN and ON (e.g. Bowerman, 1996; Bowerman & Choi, 2001; Levinson, Meira & The language and cognition group, 2003; Levinson & Wilkins, 2006). (Note that in this paper, IN and ON in uppercase will refer to the concepts expressed primarily by the English prepositions *in* and *on*, respectively: IN for the spatial concept of containment and

ON for the spatial concept of support. These are the primary meanings of the English prepositions *in* and *on*, although clearly these prepositions also have other extended and metaphorical meanings.) That these are basic topological relationships can be seen in children who at very young ages show a great deal of knowledge of the concepts of containment and support (Clark, 1973; Hespos & Baillargeon, 2001; Needham & Baillargeon, 1993; Spelke, Breinlinger, Macomber, & Jacobson, 1992). In fact, it had been widely assumed that these two concepts are prelinguistic concepts that exist in the minds of speakers of the languages because of the shared biological constraints and life experience of human beings in a shared physical world (Levinson et al., 2003; Levinson & Wilkins, 2006). Within this view, these preexisting concepts might be expected to be mapped onto words in a more or less simple and straightforward way. However, crosslinguistic comparisons of the linguistic representations of these concepts in a variety of languages are increasingly revealing a complex and diverse picture.

Cienki (1989), for example, compared the English prepositions *in*, *on* and *at* and their Polish and Russian equivalents. He found that the uses of these spatial prepositions across the three languages do not fully overlap. For example, in English, the preposition *in* is used for *a tent in a clearing*, whereas in Russian the equivalent word of *on* is used — *палатка на поляне* (*palatka* [tent] — *na* [preposition "on" taking the locative case] — *poljane* [clearing, field; locative form as indicated by the suffix "e"]), and in Polish — *namiot* [tent] — *na* [preposition "on" taking the locative] — *polanie* [clearing, field; locative form]. Cienki's analysis was based mainly on the comparison of translation equivalents and on the researcher's own linguistic intuitions about how to describe the same spatial scenes in other languages. Other researchers have used more controlled comparisons and have elicited the linguistic descriptions of certain spatial scenes from actual language users. Their studies are reviewed below.

Until the early 1990s, most discussions about the way languages convey information about spatial relationships were descriptive, reflecting authors' intuitions. An important advance was made when Bowerman and Pederson (1992) developed a tool making possible more rigorous crosslinguistic comparisons of how spatial relationships are expressed. They employed a series of 71 pictures making up the Topological Relations Picture Series (TRPS). This series was designed to encompass a wide range of scenes exemplifying possible IN and ON relationships (the TRPS has been published in Levinson et al. 2003, and in Levinson & Wilkins, 2006, pp. 570–575). The pictures selected for the TRPS reflected the authors' intuitions about how best to depict the full range of such relationships. At this point, the only practical way to proceed, given the potentially infinite number of scenes that could be imagined, is to make informed guesses about what spatial relationship scenarios one should include in the series in order to capture all the possible

relationships relevant to the languages targeted for study. Given a set of judiciously selected pictures one can empirically investigate what speakers of different languages actually say when describing the scenarios depicted. This provides an opportunity to reveal interesting differences in how various languages handle spatial relationships, based on what speakers actually say. At times, of course, it may prove necessary to expand the set of pictures used in the TRPS in order to capture distinctions researchers had not previously thought of. The present research does precisely this; it builds on the TRPS approach by extending the pool of pictures to cover scenarios believed to be relevant to Mandarin Chinese but that were absent from the original set.

Bowerman and Pedersen (1992) used the TRPS to investigate how speakers of different languages labeled particular scenes and how the scenes were grouped together into subsets based on shared spatial terms in 38 different languages. They found that scenes typically covered in English by the prepositions *in* and *on* were grouped into different combinations by speakers of other languages in terms of the spatial terms they used. Figure 1 shows examples of the different ways five languages carved up six spatial scenes by the use of spatial terms. It can be seen that sometimes the same scenes are covered by one spatial term (as in Spanish), by more than two spatial terms (as in Dutch), by two spatial terms but with different patterns of grouping (as in Berber), by two spatial terms for the prototypical support and containment scenes, and by other terms for scenes in between (as in Japanese).
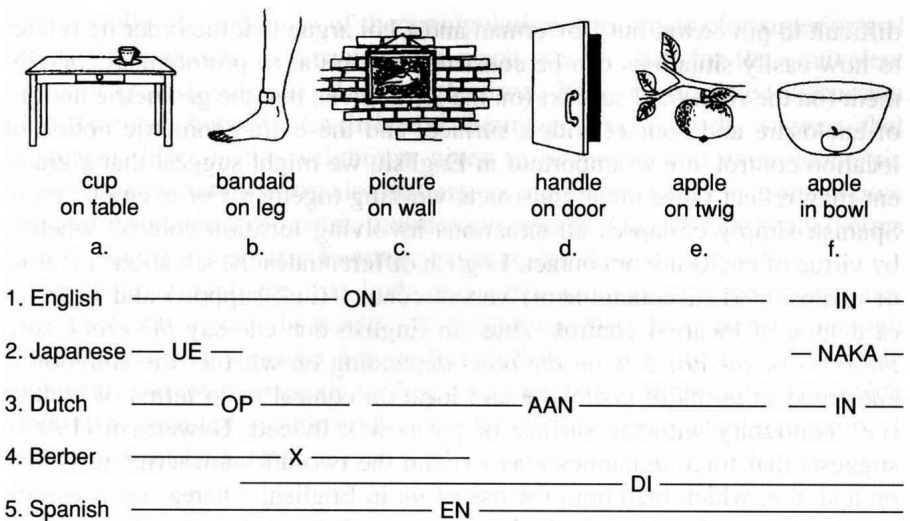

Figure 1. Crosslinguistic differences in categorizing the static topological relationships (adapted from Bowerman & Choi, 2001, Figure 16.2).

Levinson et al. (2003; Levinson & Williams, 2006) also employed the TRPS to investigate descriptions of topological spatial representation across genetically diverse languages. As Bowerman and Pederson (1992) did, they also found huge differences across languages in how the pictures were grouped by spatial terms, a result that ran counter to the idea that IN and ON are primitive holistic or fundamental concepts, and hence possibly universal. For example, in English, the spatial concepts ON (e.g., *apple on table*) and OVER (e.g., *light over table*) are seen as two distinct concepts, whereas many languages (e.g., Japanese; Arrente) conflate these by using the same spatial term. Similarly, IN (e.g., *apple in bowl*) and UNDER (e.g., *ball under chair*) tended to be conflated in Australian languages. Furthermore, the spatial scenes involving the general feature of attachment (e.g., *bandage on leg*, *clothes on clothes line*) are expressed in English by the preposition *on*, whereas they are described in many other languages by terms different from those used for scenes like *cup on table*. In addition, these concepts are encoded not just in adpositions (prepositions and postpositions), but also in verbs, by grammatical cases, spatial nominals, and adverbials.

As seen above, the TRPS tool provides a controlled basis for contrastive comparisons across languages. It can also elicit semantic subtleties that often cannot be obtained from dictionaries or grammatical descriptions (Levinson et al., 2003). The use of picture stimuli allows one to address a rich variety of linguistic treatments of the spatial relationships IN and ON to be revealed, offering a window into the cognitive underpinnings of these spatial representations. This was clear in the studies of Levinson et al. (2003), Levinson and Wilkins (2006) and Bowerman and Pederson (1992), where the seemingly simple concepts IN and ON turned out to be far more complex than previously thought.

As Levinson and Wilkins (2006) recognized, and as alluded to earlier, this kind of extensional analysis of mapping words onto pictures does not necessarily reveal nuances of the various spatial terms found in different languages. For example, some of the differences that researchers have documented might be due to conceptual variations in how IN and ON are represented. On the other hand, the fact that different linguistic terms are used to describe two different pictures does not necessarily mean that the pictures are being conceptualized differently. The difference could be one of speech register or tone. For example, English *within* is similar in meaning to *inside*, but the former sounds loftier in tone (Lindstromberg, 1997); the difference between them may be more rhetorical than conceptual.

Even when studies revealed that underlying conceptual patterns might be responsible for differences in how the TRPS pictures were assigned to the IN and ON categories across languages, it can still be unclear whether the different assignments point to completely different concepts or just to differences in semantic range. For example, as mentioned previously, IN and UNDER are conflated in

some languages but separate in others. The reason might be that IN and UNDER merge into a general concept composed of the idea of containment plus the idea of position below something. Alternatively, UNDER might also be understood as referring to a type of containment, similar to *bird in tree* where, for English speakers, the top part of the tree is treated as providing an imagined boundary enclosing (containing) the bird. Thus, in *ball under chair*, the space between the four legs of the chair may also be perceived as creating a vague boundary confining where the ball could be located.

Further in-depth studies are needed to examine the semantic underpinnings of the spatial terms used for IN and ON, in order to identify possible differences among languages in how the seemingly fundamental concepts of containment and support are represented, and most importantly, to explore the reasons for these differences. These issues are not easy to examine in studies that involve the simultaneous examination of a large number of languages, because in such studies there can be too many contrasts in the picture grouping patterns to consider. For this reason, the present study focused on two languages only. The study explored crosslinguistic variation in the representation of the topological concepts of containment and support, and the possible cognitive underpinnings, in English and Mandarin Chinese.

These two languages are interesting to compare for several reasons. First, English has been well studied in terms of the spatial concepts IN and ON and thus provides a strong basis for comparison with other languages. Second, there is very little empirical research published in English focusing on spatial language in Mandarin (Xu, 2008a, p. 1), especially research that is based on elicited responses by native speakers. This may be due to the seemingly highly similar patterns between English and Mandarin in the way they express IN and ON. At first glance, Mandarin, like English, employs two widely used words to refer to the concept of containment and support. In addition, it seems that the carving up of spatial location scenarios into the two concept categories corresponds well across the two languages. For example, in Figure 1, the categorization pattern in Mandarin is exactly the same as in English. However, some studies of second language learners of English (e.g., Larsen-Freeman, 2006) have descriptively referred to problems that Mandarin speakers have with the use of *in* and *at* in English. In China, although both language teachers and linguistics have noticed that the use of *in/on* in English and the corresponding words *lǐ/shàng* in Chinese do not fully overlap in both literal and metaphorical meanings (e.g., Tai, 1993), little research has explored in depth the reasons for these discrepancies. Among them, most studies have only attempted to provide a rough list of example differences (e.g., Guo, 2010; Yu & Ma, 2010; an exception is Wu & Wei, 2007, which will be discussed later in this paper) and none of them was based on an experimental study. The relatively few studies

on this issue stand in particular contrast to the many studies focusing on the difference between English and Chinese in the metaphorical extensions of the spatial concepts UP/DOWN, which are more noticeable than the difference between the literal meanings of IN/ON.

A pilot study we conducted in preparation for the present one revealed that there might also be significant cross-linguistic differences in the expression of the two concepts IN and ON if one looked more deeply into the matter. With these considerations in mind, and in light of previous work on this topic, the present study examined the following questions:

1. Do Mandarin and English speakers' patterns of use of the canonical forms corresponding to IN and ON, when describing stimulus pictures, suggest that the pictures are associated with the same or with different categories with respect to containment (IN) and support (ON)?
2. If there are Mandarin/English cross-linguistic differences in patterns of use regarding the IN and ON categories, do these patterns suggest systematic differences in the way the speakers may have conceptually represented the depictions of containment and support in the stimulus pictures?
3. Are there individual differences among speakers that suggest there exist *within*-language group differences in the conceptualization of containment and support?

The TRPS methodology was used to address these three questions. By means of this methodology, it was possible to elicit descriptions involving the spontaneous use of the canonical forms of IN and ON in an efficient way, thereby providing a controlled basis for comparing the range of spatial relationships (as represented by different pictures) covered by these terms in each language. For purposes of the present study, the following departures from the usual use of the TRPS were introduced. First, we identified from the elicitations all the adpositions that were used to express the spatial concepts of containment and support in English and Mandarin. Next, each adposition was classified as expressing either containment or support. Using a set of well-defined operational criteria (described below), it was then possible to determine whether each picture had been predominantly treated as exemplifying the IN or ON relationship in each language, or had failed to convincingly reflect one or the other relationship. As well, the TRPS stimulus set was expanded to include pictures of scenarios not previously part of the series. Finally, we used a large enough sample of participants to be able to apply statistical criteria for interpreting the results. Generally in TRPS research to date, informant samples have tended to be rather small. For example, Feist (2000; 2008) used from one to six participants for each language group and Levinson et al. (2003) used from one to ten informants for eight out of the nine languages they examined (and

26 informants for the ninth). It appears that scholars have tended to assume that small numbers of native speaking informants are sufficient for this type of study; for example, Levinson and Wilkins (2006) stated that "three or more consultants allow some qualitative and quantitative analysis of preferred solutions" (p. 9).

Before proceeding with the report of the present study it is necessary to first examine how English and Mandarin express the concepts of containment and support.

IN and ON in English

In English, *containment* (IN) is often expressed by the preposition *in*, for example, *The apple is in the bowl* (Conventry & Garrod, 2004; Tyler & Evans, 2003; Vandeloise, 1994; Vandeloise, 2003). *Inside* and *within* are also used to express this spatial concept, often as emphatic forms of *in*. However, the meaning of *in* is broader than *inside* or *within* insofar as *in* covers a wider range of containment situations. *Support* (ON) is often expressed by the preposition *on*, for example, *The cup is on the table* (Conventry & Garrod, 2004; Tyler & Evans, 2003; Vandeloise, 2003).

IN and ON in Mandarin Chinese

In Mandarin, containment (IN) is often expressed by the postposition 里 (*lǐ*),[1] for example:

> 苹果　　在　　　碗　里
> *píngguǒ zài*　　*wǎn li*
> apple   coverb *bowl* in
> "*The apple is in the bowl*"

Note that 中 (*zhōng*), 内 (*nèi*) and 之中 (*zhīzhōng*) can also express this concept. They sound more formal and are interchangeable most of the time with 里 (*lǐ*) (Lü, 2007). Although there are still differences in kinds of lexical combinations they can enter into (cf. Xing, 1996), the concept expressed by 中 (*zhōng*), 内, (*nèi*) and 之中 (*zhīzhōng*) is still containment (Yang, 2008; Zeng, 2005). Support (ON) is often expressed by the locative particle 上 (*shàng*), for example:

> 杯子在　　　桌子　上.
> *bēizi zài*　　*zhuōzi shàng*
> cup coverb table   on
> "*The cup is on the table*"

For additional linguistic discussions on the historical origins of these terms in Mandarin and on comparisons across different Chinese dialects, see Chappell and Peyraube (2008) and Xu (2008b).

Method

Participants

Participants were 25 native English speakers living in Montreal, Canada, and 25 native Mandarin speakers living in Harbin, China. All speakers reported themselves to be monolingual or highly dominant in their first language, which means that although some of them knew a second language, they had limited knowledge of it. The age of the English speakers ranged from 19 to 38 years and the age of the Mandarin speakers ranged from 19 to 29 years. The English and Mandarin speakers were all university undergraduate or graduate students at the time of testing.

Stimuli

The stimulus materials were 116 simple line drawing pictures, printed two to a page (top and bottom halves). Each picture was approximately 9 by 9 cm. Of the 116 pictures, 65 of the original 71 TRPS were adopted from Bowerman and Pederson (1992) (all except TRPS stimuli numbered 18, 20, 24, 33, 47, and 59 because pilot testing revealed them to be too ambiguous). An additional 64 pictures were developed by the authors to expand the possible range of the spatial relationships, creating new pictures numbered from 73 to 137 of which 13 proved to be ambiguous in a pilot study; the retained 51 pictures are shown in the Appendix.

Each picture depicted a topological spatial relationship between a located (target) object highlighted in yellow and with an arrow pointing to it, and a reference object. Together, the 116 pictures depicted relationships covering a range of situations that are usually described in English by the prepositions *against, in, near, on*, *over*, *under*, etc. The names for the located and the reference objects were printed below each picture (e.g., cup/table) in the appropriate language for the Mandarin- and English-speaking participants respectively. The items depicted were all ordinary objects commonly found in both Mandarin- and English-speaking societies, thus it was not difficult to provide translation equivalents for the names in each language. The suitability of the names was further checked and confirmed by full agreement with three native speakers of each language.

Procedure

Participants were tested individually by the first author. Each participant was given a stack of pages containing the pictures and the following written instructions in the appropriate language: "In a moment, you will see a set of pictures. Please describe where the yellow object that the arrow is pointing to is located in relation to the other black-and-white part of the picture". Names of the objects are given below each picture. The name for the yellow object is also colored in yellow".

A short interview followed the completion of the task, during which participants were asked to explain their reasons for choosing the terms they indicated for certain pictures. To prevent systematic priming effects, the order of the pages in the stack was randomized differently for each participant (using the same 25 random orders in each language, but two different orders for each participant). All responses were recorded. Participants were told that there were no right or wrong answers and that the purpose of the study was to investigate how people naturally describe these pictures.

Analysis and results

There were 5800 picture descriptions generated in total (25 speakers in each of 2 languages x 116 pictures). The data were analyzed in two phases. The first focused on similarities and differences by language group (Research Questions 1 and 2), and the second on individual differences within each language group (Research Question 3).

Similarities and differences by language group

Research Question 1:
We identified similarities and differences in how English and Mandarin speakers categorized the pictures through their usage of the canonical forms for IN and ON as follows. First, the adpositions used for each picture by each speaker were identified. It was found that a variety of adpositions were used for these 116 pictures. Second, these adpositions were then classified into three categories: (a) IN (containment); (b) ON (support); and (c) OTHER. The IN and ON category included the previously mentioned adpositions that express the concept of containment or support in English (IN: *in, inside, within*; ON: *on*) and Mandarin (IN: *lǐ, zhōng, nèi, zhīzhōng*; ON: *shàng*). The OTHER category included any other adpositions that do not belong to the IN and ON categories. Finally, the total number and percentage of IN and ON responses to the 116 pictures were calculated. The results are presented in Table 1.

Table 1. Total Number and Percentage of IN, ON and OTHER Responses to the 116 Pictures by the 25 Respondents in each Language Group

	Mandarin speakers	English speakers
IN*	860 (29.66%)	1285 (44.31%)
ON	1807 (62.23%)	1249 (43.07%)
OTHER**	233 (8.03%)	366 (12.62%)

* Includes English *in* (39.72%), *inside* (3.66%), *within* (0.93%) and Mandarin *lǐ* (19.14%), *zhōng* (9.79%), *nèi* (0.69%), and *zhīzhōng* (.03%).
** Neither IN nor ON

As Table 1 shows, the Mandarin speakers used more ON than IN, overall, compared to the English speakers, in a pattern suggesting that the concept of support was used more prevalently by Mandarin speakers than by English speakers for describing these particular pictures, whereas, for English speakers, neither concept was used more dominantly.

Further analyses were conducted to determine if the above result was due to some specific pictures being more strongly perceived in terms of support by Mandarin speakers than by English speakers, as opposed to just differential use of IN and ON adposition across all picture descriptions. For this, the total number of uses of IN, ON, and OTHER adpositions for each picture was counted for each language group. It was found that sometimes all or nearly all of the 25 speakers within a given group used the same term, and sometimes they were divided in how they described the picture. For this reason, a set of criteria was established to determine whether a given picture could be considered unambiguously IN-dominant or ON-dominant for a group of speakers in each language. Accordingly, a picture was operationally defined as IN or ON-dominant if:

a. at least 90% of the participants from each language group used a term that was either a canonical form for IN or for ON to describe the picture;
b. of those speakers using a canonical form, the number using the majority form for that picture, as a proportion of all speakers using either form, was statistically significantly (by the binomial test; $p < .05$).

These criteria are strict enough to ensure that pictures identified as either IN- or ON-dominant are unambiguously clearly so, without being so rigid as to exclude too many picture descriptions from the study. In practice, these criteria ensured that, of the 25 participants in each language group describing a given picture, at least 22 (i.e. 90%) used a canonical form of IN or ON to describe it and the absolute difference between the number using the IN versus the ON form was at least 10 participants (e.g., an 18–7 split would establish dominance whereas a 17–8 split did not, by the binomial test of significance). Using the above criteria, it was

Table 2. Number and Percentage of the 116 Pictures Falling into each of Three Categories for each Language Group

	Mandarin speakers group	English speakers group
IN-Dominant	25 (21.55%)	44 (37.93%)
ON-Dominant	61 (52.59%)	39 (33.62%)
OTHER*	30 (25.86%)	33 (28.45%)

*Pictures not qualifying as either IN-dominant or ON-dominant according the operationalized definitions used in the study.

possible to group the 116 pictures into three separate categories — "IN-dominant", "ON-dominant" or "OTHER", based on the responses from each language group. Pictures were assigned to the category OTHER when the difference between IN versus ON descriptor use was not statistically significant or when more than three people used a descriptor other than a canonical form for either IN or ON. The number of pictures in each category for each language group is shown in Table 2.

In order to identify any similarities and differences between Mandarin and English in the categorization of pictures, the pictures were further categorized into the following four groups.

– An IN-IN group: congruent Mandarin IN, English IN — pictures that consistently qualified as "IN-dominant" for both Mandarin and English speakers;
– An ON-ON group: congruent Mandarin ON, English ON — pictures that consistently qualified as "ON-dominant" for both Mandarin and English speakers.
– An ON-IN group: non-congruent Mandarin ON, English IN — pictures that consistently qualified as "ON-dominant" for Mandarin and IN-dominant for English speakers.
– An IN-ON group: non-congruent Mandarin IN, English ON — pictures that consistently qualified as "IN-dominant" for Mandarin and ON-dominant for English speakers.

For the two non-congruent classes (ON-IN, IN-ON), the following additional criterion was used to ensure that the crosslinguistic contrast was unambiguous:

– The difference between the number of English and Mandarin speakers using the containment descriptor and the support descriptor had to be statistically significant (binomial test; $p < .05$).

In this manner, 71 out of 116 pictures were identified as falling clearly into one of the four possible categories described above, as follows: IN-IN, $n = 22$ pictures; ON-ON, $n = 35$; ON-IN, $n = 13$; IN-ON, $n = 1$. Figures 2, 3, 4 and 5 show the actual pictures for each group.
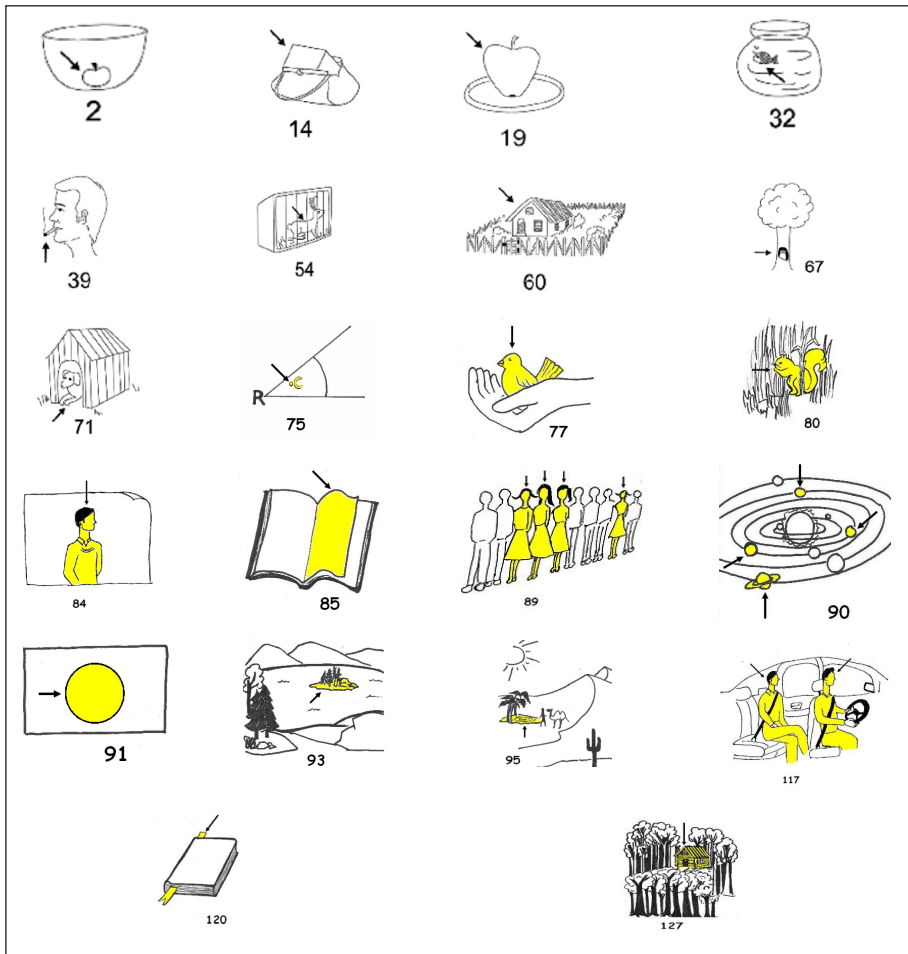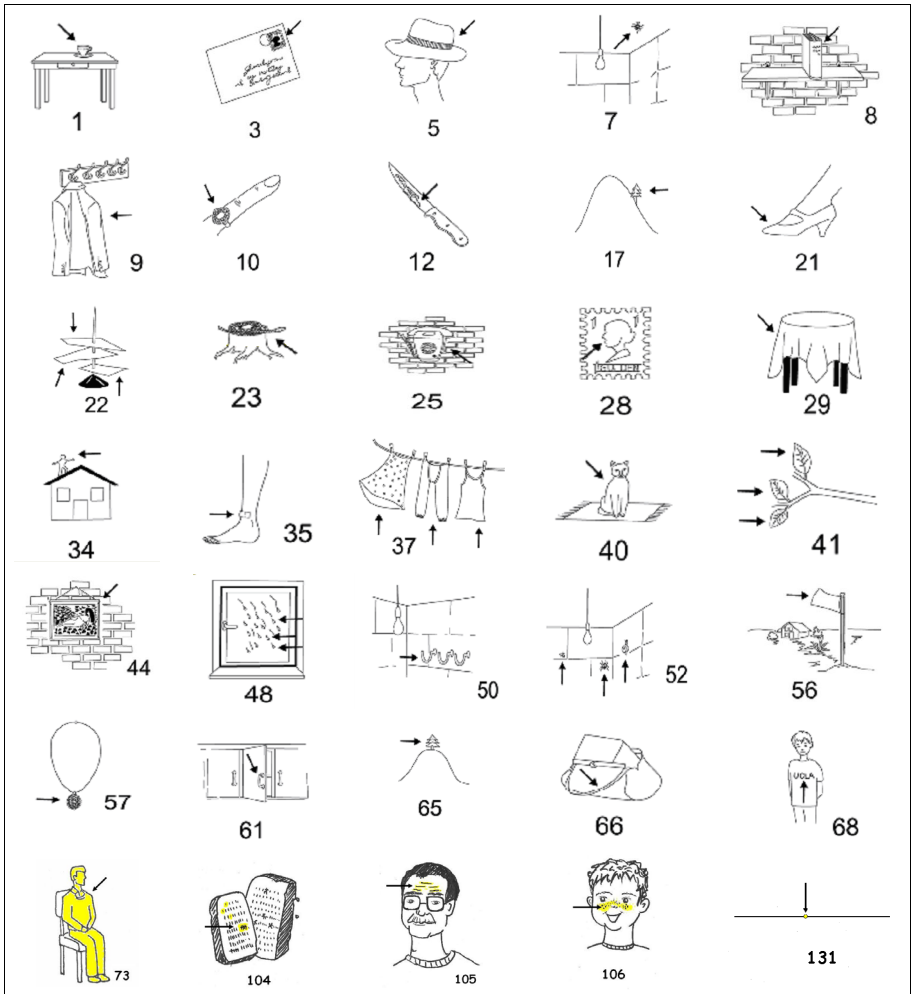
Figure 2. Twenty-two pictures that were consistently described as containment relationship in both English and Mandarin (the IN-IN picture group).

Note. Items numbered 71 or lower are from Bowerman and Pederson (1992) and those numbered 72 or higher were specifically created for this study.

Note that the IN-ON category (Figure 5) had only one element in it. To confirm that in the other three categories the use of IN and ON descriptors followed truly distinctive patterns (an outcome not necessarily guaranteed by the application of the picture retention criteria described above), the numbers of speakers using IN and ON forms for each picture were submitted to a 2 x 2 x 3 item based analysis of variance (ANOVA) (i.e., with pictures as "subjects") with the within factors being language (Mandarin, English), descriptor (IN, ON), and the grouping factor being type (IN-IN, ON-ON and ON-IN), with *n*'s of 24, 35, and 12 pictures for the three non-singular groups respectively. The important result was the

Figure 3. Thirty-five pictures that were consistently described as support relationship in both English and Mandarin (the ON-ON picture group).

Note. Items numbered 71 or lower are from Bowerman and Pederson (1992) and those numbered 72 or higher were specifically created for this study.

significant three-way language by descriptor by type interaction ($F(2,68) = 219.75$, $MSE = 1916.905$, $p < .00001$, $\eta_p^2 = .866$; see Figures 6a and 6b).

Research question 2:

The next research question addressed whether there is some systematicity underlying the pattern of similarities and differences in the way Mandarin and English speakers used containment and support terms. To answer this question, a
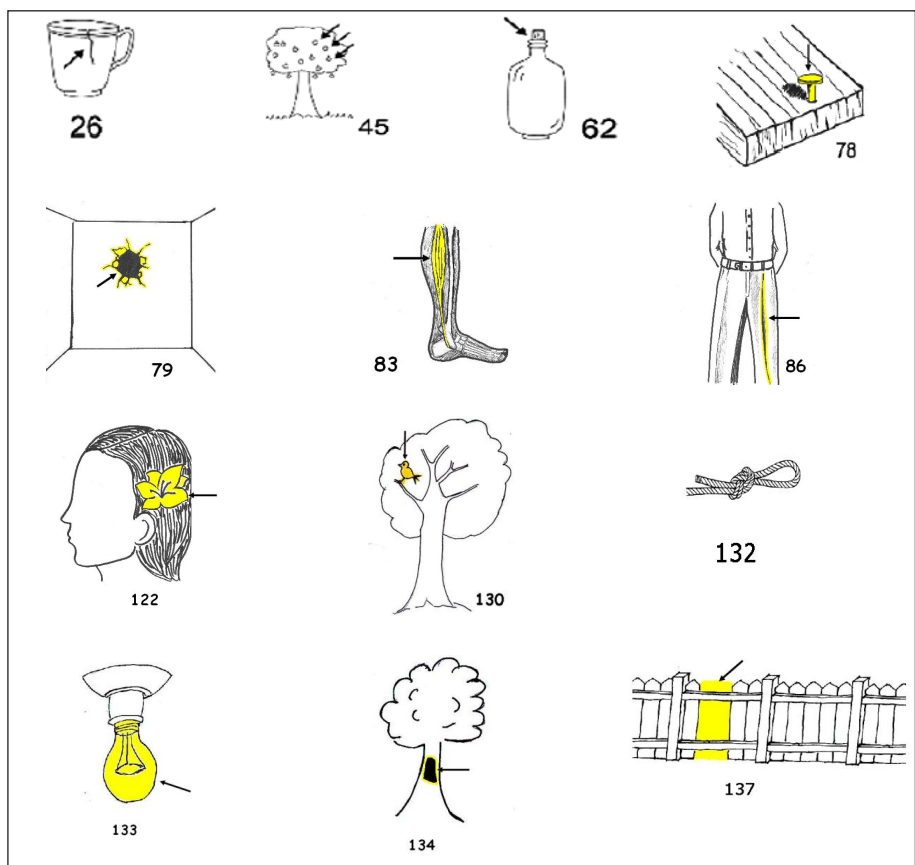
Figure 4. Thirteen pictures that were consistently described as support in Mandarin but as containment in English (the ON-IN picture group).

Note. Items numbered 71 or lower are from Bowerman and Pederson (1992) and those numbered 72 or higher were specifically created for this study.
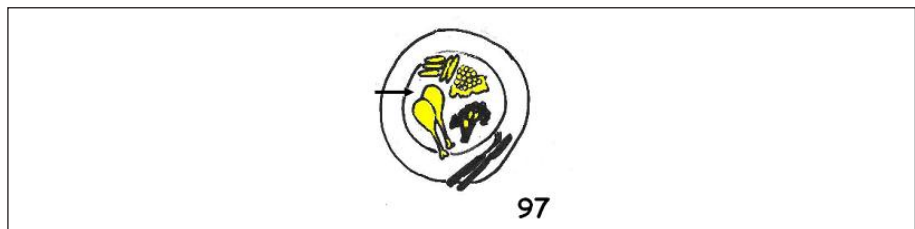
Figure 5. The one picture that was consistently described as containment in Mandarin but as support in English (the IN-ON picture group).

qualitative analysis was conducted to determine if the distribution of the pictures into each of the four categories (IN-IN, ON-ON, ON-IN, IN-ON) was consistent
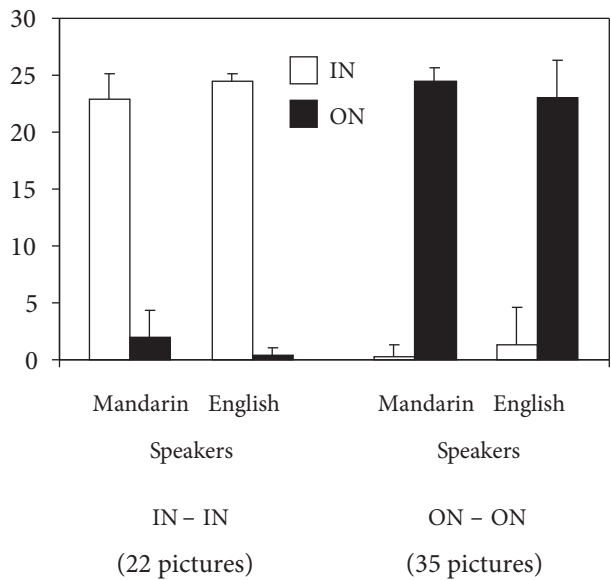
Figure 6a. Number of speakers (and standard deviations) describing the congruent (IN-IN and ON-ON) pictures using canonical forms of IN versus ON in Mandarin and English.
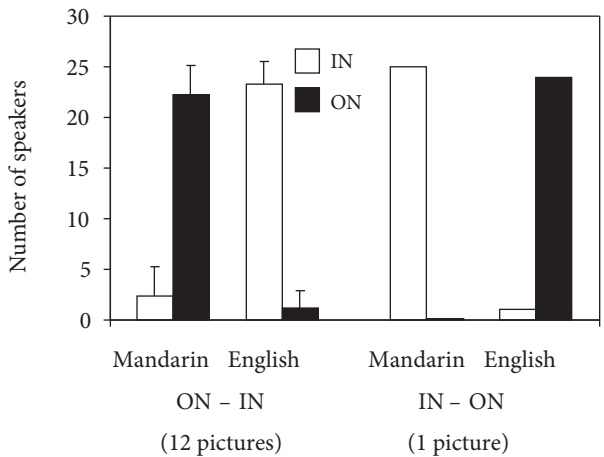
Figure 6b. Number of speakers (and standard deviations) describing the incongruent (ON-IN and IN-ON) pictures using canonical forms of IN versus ON in Mandarin and English.

Note. There are no SDs for the IN-ON category because there was only 1 picture.

in some way, supporting the possibility that there might be some underlying conceptual explanation for the similarities and differences involved.

These qualitative analyses of the responses to the pictures were generally based on the principles and criteria identified by Herskovits (1986) regarding the semantics and pragmatics of locative expressions, including case studies of the prepositions *in* and *on*. She proposed that there is an ideal meaning for a given preposition. From this ideal meaning other use types of the preposition are derived using a set of principles involving convention-based shifting and pragmatic processes of tolerance. She provided a set of examples for each use type together with the defining principles and criteria. For example, the ideal meaning of *in* is "inclusion of a geometric construct in a one-, two-, or three-dimensional geometric construct" (Herskovits, p. 149). Then she derived eleven use types from this ideal meaning. One example is that the located object is located within the outline of the reference object, for example, *bird in tree*. These principles were applied as follows to the present set of English and Mandarin data in an effort to discover cross-linguistic commonalities and differences.

IN-IN (Figure 2).

Pictures in this group were consistently described in terms of the IN relationship by both English and Mandarin speakers. As can be seen from Figure 2, the pictures exhibited one of the following IN (containment) configurations:

- the located object was fully or partially contained by a 3-dimensional reference object with a clear interior (this situation included configurations that involve the prototypical containment meaning, that is, the located object is more or less fully contained in a three-dimensional container), for example, *rabbit in cage* and *box in bag*;
- the located object was located within the space defined by *the outline of a group* of objects, for example, *squirrel in grass*;
- the located object was a member of the reference object, which consisted of a group of objects, for example, *girls in line*;
- the located object was in an interior space defined by two planes at an angle, for example, *bookmark in book*; or lastly,
- the located object was in a 2-dimensional *bounded area or geographical region*, for example, *circle in rectangle* and *island in lake*.

ON-ON (Figure 3).

Pictures in this group were consistently described as ON in both English and Mandarin. As can be seen from Figure 3, these spatial scenes also involve different situ-

ations. In most cases, the located object is supported by the reference object. The ways of supporting are diverse, as the following examples show:

– the located object rests on the surface of the reference object (this situation include configurations that are associated with prototypical support, that is, the located object is supported by and resting on a horizontal upward facing surface of the reference object.), for example, *cup and saucer on table*;
– the located object is adhered to the reference object, for example, *stamp on envelop*; *fly on ceiling*;
– the located object is joined by devices to the reference object, for example, *handle on door*;
– the located object is encircled and in contact with the reference object (Feist, 2000), for example, *ring on finger*;
– the located object is impaled/spiked by the reference object (Feist, 2000), for example, *paper on spike*.

In some cases, however, the located object can hardly be said to be supported by the reference object, but rather is part of the reference object, for example, *freckles on face* and *strap on the bag*, or is attached to the reference object, for example, *pendant on the necklace*. Nevertheless, a sense of support/contact (ON) was still present and thus both language groups used the ON adpositions to describe these pictures.

ON-IN (Figure 4).

The pictures in this set are those that were described predominantly by ON in Mandarin but IN in English. As can be seen from Figure 4, these pictures exhibited features not possessed by the previously discussed two groups of pictures (Figure 2 and 3). The first is defined by Herskovits (1986) as "Gap/object 'embedded' in physical object" (p. 150). According to this feature, the located object is included in part of the space that the reference object would have occupied if it had not been penetrated by the located object. (Interestingly, not all the examples of this type listed by Herskovits would be considered as support in Mandarin, further showing that the English preposition *in* does not apply identically to Mandarin.) Here the located objects are often what Levinson and Wilkins (2006) called "negative objects", like *hole*, *crack* or *gap*, for example *hole in wall*, *crack in cup*, *hole in tree*, *gap in fence*, but it can also involve other objects, for example *nail in board*, *flower in hair*. In these scenes, the located object is geometrically partially included in or surrounded by the reference object. However, a second feature that stands out with these pictures is that the reference objects — the wall, board, tree trump, hair, fence, and the surface of the cup — can be considered as providing a sup-

porting surface for the located object. The surface in English can be construed as a very thin lamina (Herskovits) which provides some inner space for the located object to be embedded in. In contrast, in Mandarin these spatial scenes were described using the support expression even though parts of the located objects were geometrically included and contained in the reference object. It seems that the embeddedness and inclusion aspects of the scenes did not elicit the containment conceptualization in the Mandarin speakers. In fact, the status of scenes involving located objects that are "damaged" or involve "negative space" is controversial across languages; Levinson and Wilkins (2006) have pointed out, for example, that such scenes tend not to be expressed from the spatial perspective in many languages. In Mandarin, such scenes can be described using spatial expressions, but exclusively as support (Zhang, Segalowitz, & Gatbonton, in preparation).

Two other scenes where the located object is also partially included in the reference object were *cork in bottle* and *light bulb in socket*. For the latter, both the geometrical partial inclusion of the bulb in the socket and the functional position control of the socket on the light bulb can account for why this scene is treated as containment in English (Conventry & Garrod, 2004; Vandeloise 1994, 2003). Similar reasons apply to *cork in bottle*. In Mandarin, however, even though the position and movement of the socket and cork are fully controlled by the reference objects and the located objects are partially included in the reference object, this scene was expressed using the canonical term for support. The reason might be that the inclusion segment was limited (e.g., only a small part of the light bulb is in the socket) whereas the salient part of the located object was clearly visible. The reference object's support role might have been perceptually highlighted, resulting in a support conceptualization.

There were also scenes in this ON-IN category in which the located object was the "accident/object part of physical or geometric object" (Herskovits, 1986, p. 152). Here, the located object can be an actual physical part of the reference object (*muscle in leg*) or a geometric "accident" (*crease in pants*; *knot in rope*). The data suggest that for Mandarin speakers this situation does not elicit the concept of containment, unless the object is part of a group of objects, as in the example *girls in line* discussed earlier. Rather, it is the contact between the located object and the reference object that is highlighted for Mandarin speakers. For example, in the case of *muscle in leg*, from an anatomical perspective the muscle is contained within the leg; however, the apparent visibility of the muscle may have been salient for the Mandarin speakers.

The final pattern in this category involved the two spatial scenes *fruit in tree* and *bird in tree*, in which the located object was contained within the outline of another object. Here, the bird and fruit can be construed as being located within the volume bounded by the outline of the tree's branches. Earlier, we discussed a

similar case concerning *squirrel in grass* and *house in woods*. The difference between these two pairs is that the reference object in *fruits in tree* and *bird in tree* is an individual object (tree) whereas grass is composed of many blades and woods is composed of many trees. In Mandarin, it would seem, a single tree is not normally construed as a container that can hold birds and fruits within its outline; containment here would imply that the object was inside its trunk. Thus, instead of perceiving the salient relationship as one of containment, Mandarin speakers perceived it as the contact of the bird or fruits with the tree or part of the tree, for example, the branch.

IN-ON (Figure 5).

Fourth, and finally, there was only one picture that was described using the term for containment in Mandarin but support in English — *food on plate*. Here, the food was surrounded and contained by the plate, but also supported by the plate.

Interestingly, the typical Chinese plate is usually not particularly flat, but has a concave bottom, more like a bowl. This example may simply reflect the difference in object knowledge (see later discussion) between the two languages — the assumption that the depicted plate was deep (bowl-like) by Mandarin speakers but flat by English speakers. More research on this category is needed.

In summary, these qualitative comparisons revealed that pictures in the ON-IN category (Mandarin ON-dominant, English IN-dominant) had some consistent features not present in the two congruent picture groups (IN-IN and ON-ON), and these features could account for the systematic differences in how English and Mandarin speakers used terms in their respective languages for the spatial concepts of containment and support. Configurations depicting a located object partially embedded in a two-dimensional surface, or as part of a single reference object, or located within the outline of a single object seemed to be consistently described in Mandarin by the ON term reflecting support but in English by the IN term reflecting containment. Also, located objects like "hole", "gap" and "crack" were often described by terms associated with the concept of support in Mandarin but containment in English.

Individual differences within language groups

As mentioned earlier, it was possible to identify for each language group a set of representative IN (IN-dominant) and representative ON (ON-dominant) pictures. However, the speakers within each language group did not always provide a unanimous pattern of responses for every picture. Sometimes, a few individuals provided answers to particular pictures that were at variance with the dominant

response for that speaker's language group (e.g., responding with an IN word to pictures meeting the criteria for being classified as ON-dominant for that speaker group). It is especially worth noting how two individuals responded to certain pictures in the ON-IN subset (Figure 4), opening up the possibility that these individuals were conceptually representing the pictures to some extent in a way more similar to members of the other language group than to their own group.

For example, in the Mandarin group, informant MU described the following five scenes in terms of containment instead of support, contrary to what most of the other Mandarin speakers did, saying *light bulb in socket*, *gap in fence*, *nail in board*, *hole in tree* and *muscle in leg* instead of using Mandarin *shàng* to say *light bulb on socket*, *gap on fence*, *nail on board*, *hole on tree* and *muscle on leg*. Her description of these scenes in terms of containment relationship could even be said to sound somewhat non-native like in Mandarin. It was not clear why MU only showed departure from the majority pattern for these five pictures and not for the rest of pictures shown in Figure 4. In the short interview following the picture description test, MU was asked about why she described the pictures as she did. She replied that the muscle is contained by the leg, the nail and socket are embedded in the reference object, and the hole penetrates into the tree trunk. For *gap in fence*, she could not give a clear reason. It seemed that the feature of geometric partial inclusion was one of the factors leading MU to choose the containment perspective.

In the English group, informant ET described the following four scenes in terms of support, saying *crack on cup*, *knot on rope*, *cork on bottle* and *nail on board* instead of using the dominant pattern for English speakers *crack in cup*, *knot in rope*, *cork in bottle* and *nail in board*. ET could not provide reasons for choosing to describe the scenes from a support perspective, saying simply that these scenes look like "on" to him.

These individual differences do not seem to be random errors. Instead, they seem to reflect the possibility that the individuals had adopted different concepts from the norm for their language group. This conclusion is consistent with the fact that the Mandarin speaker MU was able to justify most of her answers. As for the English speaker ET, although he could not explain his choices, it seemed unlikely that these choices were simply a result of carelessness or random error, given that his pattern actually conformed to the way Mandarin speakers typically described these pictures.

To determine statistically whether the choices made by speakers like MU and ET in the ON-IN group were indeed systematic and not idiosyncratic or random errors, the results were subjected to a binomial test as follows. Mandarin participant MU provided only one IN word response (*lǐ*) to the 35 pictures that were ON-dominant for both Mandarin and English speakers. Given that both language groups treated these pictures as representing a support spatial relationship (ON),

Table 3. Data from Participants whose Response Patterns Deviated Significantly from their Home Language Group and that Resembled those of the other Language Group, on Trials Involving Pictures that were ON-Dominant for Mandarin Speakers and IN-Dominant for English Speakers, and Using as Baseline the Response Deviation Patterns for Pictures that Were Similarly ON-Dominant and IN-Dominant in both Languages

Participant	Language	(A) Deviation rate for ON-IN pictures	(B) Baseline deviation rate for ON-ON & IN-IN pictures	p *
MF	Mandarin	4/13 = .308	1/35 = .029	< .0001
MK	Mandarin	3/13 = .230	3/35 = .086	< .0205
MR	Mandarin	2/13 = .154	1/35 = .029	< .006
MS	Mandarin	2/13 = .154	0/35 → 1/35 = .029	< .006
MT	Mandarin	2/13 = .154	1/35 = .029	< .006
MU	Mandarin	5/13 = .385	1/35 = .029	< .0001
MV	Mandarin	2/13 = .154	0/35 → 1/35 = .029	< .006
MX	Mandarin	4/13 = .308	1/35 = .029	< .0001
EH	English	3/13 = .231	1/22 = .045	< .0022
ET	English	4/13 = .308	1/22 = .045	< .0002

* Binomial test, for the deviation rate (A) being significantly different from zero, given the baseline level (B). Where the baseline deviation was 0/35 or 0/22 (for ON- and IN-dominant pictures in both languages respectively) the binomial probability cannot be calculated and so the value of 1/35 or 1/22 was used instead. These numbers are conservative because the actual observed base rate was 0.00 in these cases.

MU's single *lǐ* (IN) response can be interpreted as an idiosyncratic response, because in general neither speaker group tended to use IN words for these pictures. MU's rate of such idiosyncratic responses can thus be estimated to be 1/35 or .0286, given she made one such response on 35 trials with ON-dominant pictures. Thus, her idiosyncratic responses would appear to be a relatively rare event. In the case of the Mandarin ON-dominant / English IN-dominant picture set (ON-IN), however, MU deviated from the Mandarin group's response pattern five times in 13 trials by responding *lǐ* (IN). The statistical question, then, is whether 5/13 is significantly different from 1/35; if so, then we can reject the null hypothesis that MU's IN responses for the ON-IN pictures (ON-dominant for the Mandarin speakers) reflected only idiosyncratic responding. By the binomial test, this result was indeed statistically significant at $p < .00003$; 5/13 is statistically significantly greater than 1/35. A similar calculation was made for English speaking participant ET who responded 3/13 times with *on* for pictures that were IN-dominant for English speakers but only 1/22 times with *on* for the pictures that were IN-dominant for both language groups. In all, ten participants (including MU and ET) appeared to deviate in this manner from their own language group. Their responses

are shown in Table 3. Together, these results show that it is possible to distinguish between cases where individuals depart from their own speaker group's pattern of responses in a systematic way from idiosyncratic cases where individuals depart in a nonsystematic fashion.

Discussion

This study set out to compare the linguistic realizations of the topological spatial concepts of containment (IN) and support (ON) between English and Mandarin. The aim was to identify differences, if any, in how speakers of these two languages use terms to express these concepts, which might initially seem to be fundamental concepts, and to explore the underpinnings of these differences. The main results were that there were both systematic similarities and differences between the way native speakers of Mandarin and English described stimulus pictures depicting a range of examples of containment and support. Most of the cases of cross-linguistic disagreement occurred with configurations described by Mandarin speakers as support and by English speakers as containment (the ON-IN picture set shown in Figure 4). Interestingly, the pictures in this set had particular features not present in the picture sets IN-IN and ON-ON where containment and support terms were used respectively congruently across the two languages, and these particular features appeared to play a role in how the speakers of these languages conceptualized the scenes as examples of containment or support. In addition, there were certain individual differences within language groups, in which some speakers, but not all, used terms for containment and support for certain pictures in the ON-IN set in ways that deviated statistically significantly from the dominant pattern of their respective language groups.

The findings support the arguments of Levinson and colleagues (Levinson et al., 2003; Levinson & Wilkins, 2006) against IN and ON being universal concepts in the sense that there is the same consistent one-to-one mapping of linguistic devices to the spatial relationships of containment and support. Instead, these concepts are compositional and include notions like horizontal support, surface-surface contact, adhesion, etc. The compositionality of the concept of containment was also discussed by Vandeloise (1994, 2003, 2005), who argued that the concept of containment consists of a set of properties, including both geometrical and functional factors. Prototypical containment or support occurs when nearly all the properties are satisfied; extensions of the concept of containment or support occur when only a subset of the criteria is met. Crosslinguistic differences occur in these extended situations. For example, the comparison of Mandarin and English revealed convergence in the prototypical uses of containment and support (e.g.

picture 54 in Figure 2 — *rabbit in cage* and picture 1 in Figure 3 — *cup and saucer on table*). On less prototypical cases there can be cross-linguistic agreement but there can be divergence as well (e.g., the pictures in Figure 4).

Naturally, the question arises about why English and Mandarin differ in the extended uses of the two concepts. Research on the semantics of spatial terms, like English *in* and *on*, suggest that a set of factors influence how speakers apply them, including geometric, functional, and object knowledge (Cienki, 1989; Coventry, 1999; Coventry & Garrod, 2004; Herskovits, 1986; Feist, 2000; Feist & Gentner, 2003; Vandeloise, 1994, 2003, 2005). These three factors will be considered in turn.

Geometry, without doubt, is an important factor distinguishing the use of English preposition *in* and *on*. *In* typically means that the located object is in the interior of the ground, whereas *on* typically means that the located object is in contact with the reference object. This applies to Mandarin as well. However, geometry alone cannot explain all the uses of *in* and *on*. For instance, as Herskovits (1986) has pointed out, the topmost book of a stack of books can be said to be on the desk even though it is not contiguous with the desk. Likewise, a piece of bread completely covered by an upside down bowl is described as *under the bowl* even though, from a geometric point of view it is entirely within the confines (i.e., *in*) of the bowl. According to Coventry and Garrod (2004), the degree of the *location control* that the reference object applies to the located object accounts for the suitability of *in* and *on* in the above two situations. For an x to be in or on y, y should be able to control the movement of x. In the book example, the topmost book is not in contact with the desk but the desk nevertheless has a strong control of its movement (e.g., if someone lifts the desk, the book would move along with it). Thus, *on* can be used. In the case of the bowl covering the bread example, while the bread is included in the bowl geometrically, the bowl has a very weak control of its movement (lifting the bowl would not displace the loaf of bread). Thus, *in* is not — or is much less — appropriate. Thus, in English, functional considerations appear to be very important.

The geometrical and functional factors also apply to the use of the two concepts in Mandarin. However, geometry factors would appear to be weighted more than function factors in Mandarin, at least for dealing with the stimuli presented here. For example, while the concept of *support* and *under* are appropriate for the *book/table* and *bread/bowl* examples respectively in Mandarin, for the latter, containment is also acceptable in Mandarin. Furthermore, as discussed above, the light bulb/socket scene in Figure 4 is often used (e.g., Vandeloise 1994, 2003) to show the importance of function control for the concept of containment. However, as this study revealed, this scene in Mandarin was described as support. The same thing is true for cork/bottle and flower/hair scenes in Figure 4. It would seem that in these cases the amount of physical inclusion or penetration of one object into the other is sufficiently low that the scene did not compel expression as

containment to Mandarin speakers. Nevertheless, when the degree of inclusion is strong, the conceptualization of containment is acceptable in Mandarin, even though the function of location control is weak. This explains why the bread/bowl example can be expressed as containment in Mandarin, but not in English.

The role of inclusion is evident in another example: *passengers in/on the bus*. As Herskovits (1986) suggests, in English, although passengers are included in the bus geometrically, the expression *passengers in the bus* is allowed only when the bus has lost its function of transportation, for example, "Children are playing in an abandoned bus". In contrast, in Mandarin, it is perfectly acceptable to say "passengers in the bus" regardless of whether the bus is being viewed a form of transportation or not. In general, the respective importance of the geometrical and functional properties might be one of the reasons why there are certain variations between English and Mandarin in terms of the conceptualization of two concepts.

Object knowledge is another factor responsible for the difference between English and Mandarin in the conceptualization of containment and support. Languages may differ in the way that objects are conventionally conceptualized (Bowerman, 1996). For example, Cienki (1989) argued that English, Russian and Polish have different criteria for determining if a two-dimensional reference object has an interior or not (e.g., clearing and desert), which explains why certain scenes are conceptualized differently across speakers of these three languages. A similar statement was made by Chinese scholars like Wu and Wei (2007). They claimed that when reference objects are two-dimensional "areas", such as mirror, world, desert, or village, these words can only be combined with the preposition *in* in English, whereas in Mandarin it is "in the mirror/desert",[2] "in/on the village", and "on the world". These examples can be taken to show the difference between how English and Chinese speakers conventionally conceptualize these objects, although it is unclear in the statements by Wu and Wei what "area" really refers to, because the notion of area itself is language dependent. For example, why are both world and mirror considered as two-dimensional areas, when mirror has a clear visible boundary whereas world does not? It was found in the present study that the difference in object knowledge as reflected between English and Mandarin is not restricted to only two dimensional objects, but can also include other objects. For example, in Mandarin, "tree" is not usually conceptualized as a three-dimensional container, unless the focus is the trunk of the tree. "Plate" is conceptualized as a container just like a bowl in Mandarin, whereas in English it is conceptualized as a supporting surface. In addition, it seems that in Mandarin, objects like wall, fence, board, road, line (the geometrical line), as well as the outer surface of objects are usually conceptualized as providing a two-dimensional surface for supporting objects. In English, these objects can be seen as providing a very thin lamina in which the located objects can be embedded (e.g., a crack).

The findings in this study offer some potential insights into the interaction between the human conceptual system, language and the spatio-physical world. Tyler and Evans (2003) point out, for example, that the complex interaction between human conceptualization, language and the spatio-physical world is clearly reflected in the diverse use of spatial particles. In the present case, the use of *on* in *wrinkles on forehead* (picture 105 in Figure 3), for example, does not completely correspond to the prototypical meaning of ON. However, for English speakers this scene resembles the relationship of support and thus triggers English speakers to describe it using the preposition *on* (Herskovits, 1986). The same holds for Chinese speakers. Furthermore, this spatial sense of ON can be metaphorically extended to many non-spatial meanings, for example, *a book on Africa*.

The complex nature of human conceptualization is also reflected by the fact that the same spatial scenes can be construed from different perspectives. For example, one can say both "*The boat is in/on the river*" in English, depending on speakers' perspectives and the context. This complexity of human conceptual system is even more evident in the crosslinguistic differences found in this study. The present study revealed how the spatial relationships of containment and support can be construed differently in different languages.

Similarly, just as there are variations across languages in spatial representation, there are also individual variations within a language group. This point is rarely mentioned in the literature. However, a more general point noted by Jarvis and Pavlenko (2008) is that conceptual representations of lexical, grammatical, and discursive structures are not necessarily identical within the same speech community. They are subject to individual variation. For example, ranking of the hierarchical structure of objects is influenced by the judges' experience and familiarity with the objects (Murphy, 2002). In the present study, despite the relatively stable nature of the spatial concepts in a given language, these concepts are nevertheless subject to individual differences. Presumably this is because language does not refer directly to the real world but to the speaker's construal of the relationships in the world — the reality that is interpreted and shaped by the conceptual system. Under certain circumstances, one may choose to emphasize a different feature in the spatial configuration that is either unnoticed or not highlighted by the majority speakers from the same language group, but are more regularly well identified by speakers of another language group.

Finally, the results of this study have an important methodological implication. The study identified some systematic individual differences within a given language group. This finding underscores the fact that the number of participants for such studies employing picture stimuli is crucial. Studies with an *N* of 1 may produce misleading results. The existing literature tends to assume that the way spatial representation conveyed in a language is relatively fixed, and that all

members of the language community use the language in exactly the same way. Contrary to this assumption, the present study revealed that there can be systematic cases where speakers diverge from the majority of the language group, even in speaking about something as seemingly straightforward as IN and ON spatial relationships.

In conclusion, this study revealed systematic similarities and differences in the linguistic expressions of the topological spatial relationship of containment and support between Mandarin and English speakers, as well as systematic individual differences within each language group. These findings suggest that there are underlying differences between English and Mandarin speakers in the conceptualization of these two spatial concepts, although clearly future research needs to investigate these potential differences using designs that target the relative role of functional versus spatial perceptual factors associated with how speakers view the relationships depicted in the TRSP stimuli and that explore the boundaries between categories for speakers of each language, perhaps using techniques similar to those described in Coventry and Garrod (2004) and Garrod, Ferrier, & Cambell (1999). The present research adds to the body of findings indicating that the once seemingly fundamental concepts of IN and ON are turning out not to be universal concepts. The crosslinguistic variations between language groups and within language group revealed in this study point to the complex nature of human spatial conceptual system and how it maps onto language.

Acknowledgements

Notes

1. The lexical category of locative particles such as *lǐ* and *shàng* is controversial. They are considered as postpositions (Ernst, 1988; Tai, 1973), parts of circumpositions (Liu, 2002) or nouns by most scholars. In this paper, they are being called postpositions. Moreover, in addition to the spatial meaning, *shàng* also has other non-spatial meanings. Even when *lǐ* and shàng are used for their spatial meaning, syntactically they can be used as adjectives, nouns or postpositions,

depending on their position and function in the sentences. In the present paper, only the static topological spatial meanings which are expressed through the combination of noun+ *shàng /lĭ*, are discussed.

2. However, our data suggest that both "on/in the desert" are acceptable to Mandarin speakers.

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Appendix

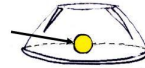The 51 supplemental elicitation pictures created for use in this study.
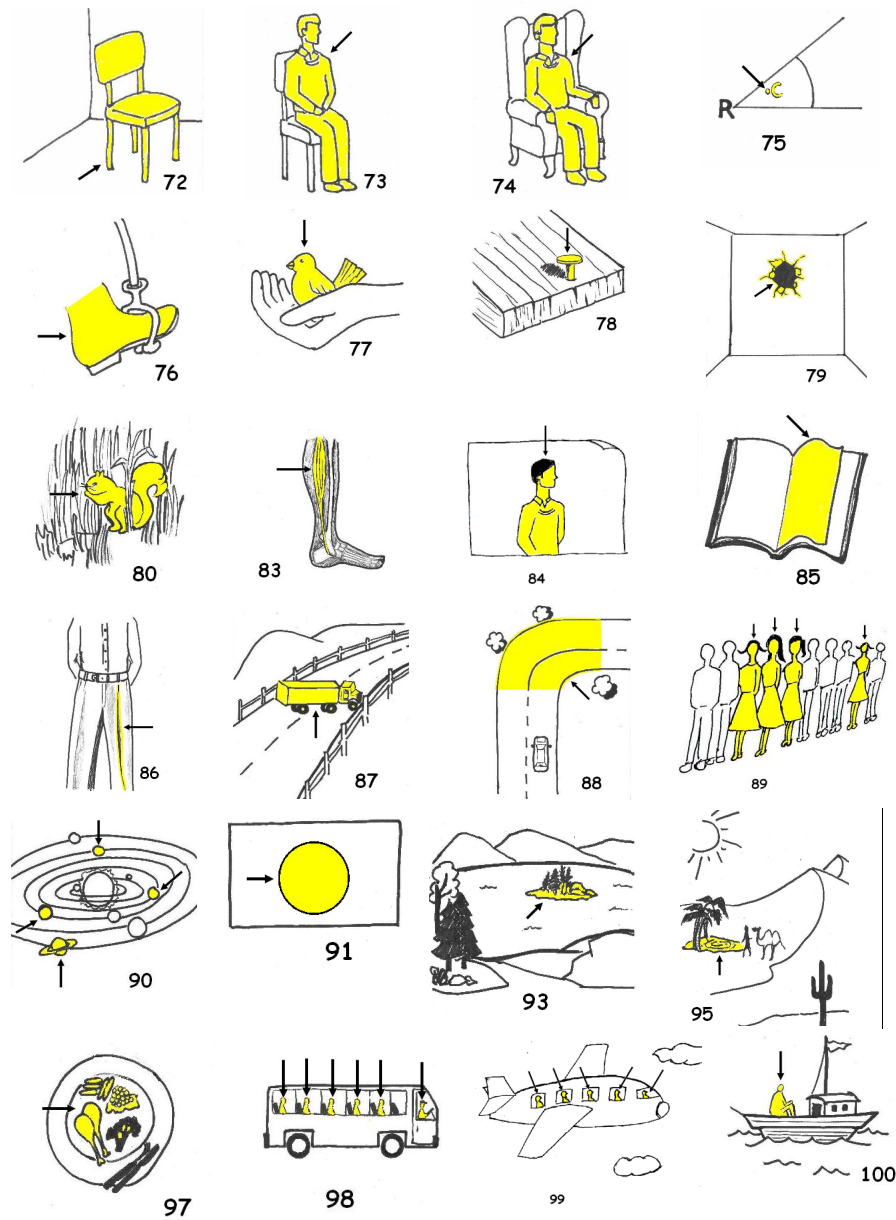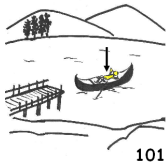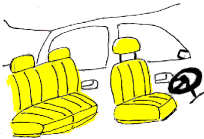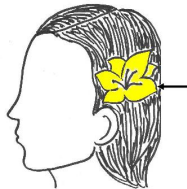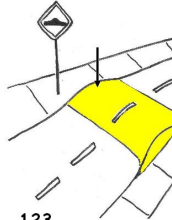
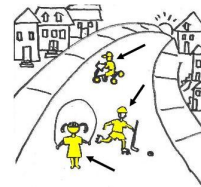101
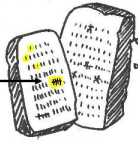
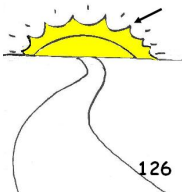104

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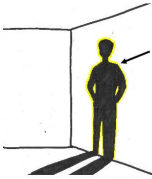
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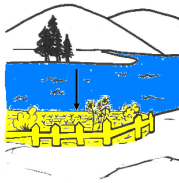
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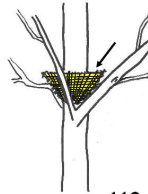
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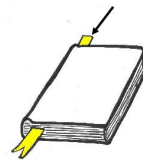
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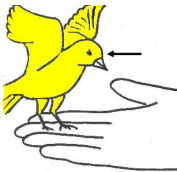
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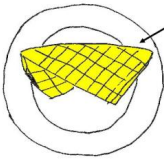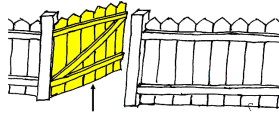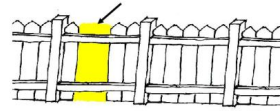129

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