The argument that the different word types use separate underlying cognitive apparatus and serve different functions also supports the idea that there are separate and different "what" and "where" systems. According to this "functional design of language hypothesis" language develops to support a set of specific functions. The mechanisms that develop in the language are matched to the system being used. There are few spatial prepositions because that is all that is needed to support the spatial-perceptual system. There are many count nouns because we need to communicate the many object distinctions (but not shape distinctions) that need to be communicated. One can no more say that the "shape" system is rich and the "spatial" system is weak than that human pattern recognition is rich and human perception is weak.

No perception without representation

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Whatever we can talk about we can also represent. This is a key principle behind the arguments of Landau & Jackendoff (L & J), and, stated at this level of generality, it is certainly hard to take exception. No claim is made about the form of the representation – it could be abstract symbols, single neuron activity, or population firing patterns. The claim is simply that language is not magic. Each linguistic ability requires some underlying representational ability.

What is true here for language is, most likely, true more generally. There is no perception without representation. Indeed, there is no perceptual or motor ability without representation. Denoting such an ability A, and a representation R, we can write this dictum as $A \rightarrow R$.

L & J actually use the converse of this principle: $\neg A \rightarrow \neg R$. They show, with very thorough and illuminating examples, that our linguistic abilities for describing "where" are very limited. Thus, $\neg A$. From this they conclude $\neg R$, namely, our "where" representations are very limited.

Airtight? Only if L & J have really established $\neg A$, and they have not. To establish $\neg A$ it is not enough to show a limited ability with "where" in our language system; one must show this limitation in *all* of our perceptual and motor systems. If there is even one perceptual or motor system in which we have a richer ability with "where," then, by $A \rightarrow R$, we must posit the corresponding richer representation.

I think there are such systems. Consider Michael Jordan, for example. During the NBA playoffs he sank six 3-point shots and amassed 35 points in a single half – from every position on the court and every possible orientation (or so it seemed) of his body in space. Put Jordan somewhere on the court and ask him to describe where the basket is. Ten to one, you could not make even a layup based on his description. Now hand him a basketball and ask him where the basket is. Ten to one, you will soon believe he knows, and without a word spoken. After asking him repeatedly from different positions and orientations, you will soon believe he has a very rich ability with "where" – and thus, by $A \rightarrow R$, a very rich representation of "where."

Objection: This is a highly trained ability in a talented man. True. But most of us can at least hit the rim most of the time, and swishes are not needed to make this point.

Objection: Baskets are simple objects, hardly a case in which complex "where" interrelations are needed. True. But remember that those 35 points came with 9 other men on the court (5 desperately trying to stop him by any means the refs could not see), and with thousands of fans not exactly in quiet meditation. "Where" relations were changing rapidly even after he began a shot. (Most of us, once again, will not score in such conditions, but we will at least hit the rim.) And in the NBA it is often the spatial relationships of objects around and above the rim that are changing all the time.

Objection: Though other things may change position, the basket does not, so this is still a very special case of "where" ability, and therefore does not imply a more generally rich "where" representational system. Perhaps. But Jordan also made a number of assists, and the "where" targets for his passes, as well as those trying to defend against them, were, well, all over the place and not standing still. It is hard to imagine a much richer environment in which to exercise and display your "wheres." To get to Pippin you must go through Drexler and around so and so and over so and so and . . . well, no wonder his tongue hangs out. Most spatial relationships for which there are prepositions and, I claim, many more for which there are none, are being exercised.

Perhaps there are objections that are fatal to the Jordan example. It seems certain, though, that many other plausible examples can replace it – examples from other sports, everyday physical activities, experiments in stereo probe placements or structure-from-motion probe placements (Braunstein et al. 1992), or other psychophysical experiments. And that is the problem with the task that Landau & Jackendoff have set themselves. They are trying to set *upper* bounds on the complexity of our "where" representations, but the data they collect can really only set *lower* bounds. And in this regard they have done a great service. I come away from their target article with a new respect for and understanding of the representational capacity of our "where" system. It is almost surely no less sophisticated than they have described. And many NBA fans count on it being much more.

Evolution and physiology of "what" versus "where"

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The target article by Landau & Jackendoff (L & J) documents and explores important differences between spatial and object-based representations as expressed in language. Because their article necessarily skimps on the evolutionary background and physiological underpinnings of these two realms of perception, my comments will highlight those issues.

It might be noted that the first explicit discussion of "what-versus-where" systems was a four-man symposium published in 1967 in *Psychologische Forschung*. Schneider (1967) dealt mainly with an attempt to distinguish tectal and cortical visual functions as orienting versus discriminating, and one could argue that his stripe-discriminations do not constitute "object vision." The other three participants (Trevarthen [1968], Held [1968], and Ingle [1967]) actually focused more on perceptual distinctions between spatial and object vision, using examples from humans, monkeys, and fish.

It would be of great evolutionary interest to devise tests comparing the number of spatial distinctions versus the number of object discriminations animals make. Most animal psychologists would probably support my prediction that there are smaller differences between rodents and primates (including man) in spatial route-finding or object-retrieval than in object discrimination skills. Thus, an evolutionary explosion of object-classification abilities in the higher mammals probably precedes language capacities, and may be a precondition of language.

L & J seem to fall into an error common among physiologists in discussing the relationship of low-level cortical processing (color, orientation, motion coding) to the shape/space dichotomy. It is quite clear that lines and edges can define the three-