Perceptual and Motor Skills, 1995, 81, 531-546.

SPATIAL CONCEPTS AND PERCEPTION OF PHYSICAL AND DIAGRAMMED SCENES [1]

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Summary.—The accessibility of objects in mental spatial frameworks depends on their relation to the spatial axes of the world and people's typical interactions with space. The current study investigated perception of space. Subjects viewed either a physical model of a person surrounded by objects (Exp. 1) or diagrams of scenes (Exp. 2). Subjects named objects at directions from their own external perspective. For physical scenes, subjects were faster to name objects at Above/Below locations, followed by Front/Behind locations, followed by Left/Right locations. This finding indicates that subjects used spatial frameworks to locate objects perceptually. For diagrams, response times to name objects did not conform to this pattern, perhaps because the spatial axes of a diagram do not correspond to stable spatial axes of the world.

We live in a world with a definite spatial structure, and experience it through senses related to the structure of our bodies. Perception and experience in space provide the bases for our concepts of space. These concepts include our understanding of spatial relations such as above and below, in front of and behind, and left and right. The physical world provides certain regularities for experiencing the world that can be internalized by the human mind (Shepard, 1987). The gravitational axis, for example, is the only fixed spatial axis in our environment that has a definite up/down directionality. This axis, then, affords an environmental concept of above and below in a way that the environment does not define a ubiquitous external left and right. Although we may apply labels like left and right to regions in familiar places such as our office, these concepts are transitory and context-dependent (see Rigal, 1994).

The nature of our bodies, with their three axes, and our perceptual and motor apparati, with the eyes and limbs facing forward, determine how we can experience spatial relations, and hence how we can think of them. In the

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[1] This research was sponsored by the Air Force Office of Scientific Research, Air Force Systems Command, USAF, under grant or cooperative agreement number, AFOSR 94-0220, and by a Research and Scholarship Development Fund grant from Northeastern University to the first author. We are grateful to Bhuvana Narasimhan and Virginia Ricker for their assistance in conducting this research. Please send correspondence to David Bryant, Department of Psychology, 125 Nightingale Hall, Northeastern University, Boston, MA 02115 (e-mail: bryant@neu.edu).

strongest sense, our experience in space determines the ways in which it is fundamentally *possible* for us to conceive of space. To a sea urchin, with no bilateral plane of asymmetry, the concepts of front, back, left, and right—so crucial to our way of thinking of space—would have no meaning. The goal of this paper is to explore how regularities of the physical world and our perceptual experience have become internalized in the spatial concepts that guide our perception of physical and diagrammed scenes.

This brings us to the major theme to be explored in this article. The spatial concepts we possess determine how we think about and act in space. As we have argued, though, these concepts carry the stamp of our experience. Our actions, deriving from spatial concepts, should reflect the nature of our perceptual experience and the regularities of the world that have the character of our spatial thought.

Classes of Spatial Representation

The impact of spatial concepts has been assessed experimentally by measuring differences in time to mentally access or retrieve locations in space. Differences in response times across different distances (Glenberg, Meyer, & Lindem, 1987; Morrow, Greenspan, & Bower, 1987; Wagener-Wender & Wender, 1991) or directions (Bransford, Barclay, & Franks, 1972; Franklin & Tversky, 1990; Logan, 1995) are assumed to reflect the use of a conceptual representation. Spatial concepts render certain relations more accessible, or retrievable, on the basis of the physical properties to which they refer. For example, objects near to one are easier to interact with than those that are far away. Thus, our concept of near is, in part, defined as a set of locations in which objects are more readily accessible. In numerous studies, researchers have found that people are faster to name objects near to themselves (Hirtle & Jonides, 1985; McNamara, 1986) or a protagonist in a story (Glenberg, *et al.*, 1987; Morrow, *et al.*, 1987) than far-away objects or antagonists.

The alternative to a conceptual representation is the equiavailability hypothesis (see Franklin & Tversky, 1990; Logan, 1995), which proposes that spatial representations have properties similar to viewed pictures (see Franklin & Tversky, 1990; Levine, Jankovic, & Palij, 1982). Levine, *et al.* (1982) described a strong version of this hypothesis, arguing that cognitive maps are picture-like and embody the properties of visual images. In particular, as in a viewed picture, all parts of the spatial representation are equally accessible to attention because no direction is given any special status. The underlying representation need not be a visual image. One might store spatial relations as a set of direction-object associations or propositions of equal strength. The main feature of this model is simply that all directions and spatial relations are represented in the same way and are afforded equal accessibility to cognition. Levine, *et al.* (1982) found evidence supporting this hypothesis for the learning of simple mazes.

Spatial Frameworks

Franklin and Tversky (1990) and Bryant, Tversky, and Franklin (1992) have sought to characterize the mental representation of one common situation, a person surrounded by objects. Although simple, this situation has ecological validity as well as being tractable. Most of the time, people find themselves in environments with objects located more or less to the sides of their bodies. They keep track of the relative locations of the objects as they turn or move in the environments. It is also common to interact primarily with objects located in front of one.

In a series of experiments, subjects read descriptions of scenes and kept track of where objects were located. Memory was tested by having subjects retrieve objects in response to probes that specified a particular direction with respect to the observer. The critical measure was the response time to retrieve an object depending on the direction probed.

It was proposed that readers would create a class of conceptual representation called *spatial frameworks* to retain scenes in memory. A number of researchers (e.g., Clark, 1973; Levelt, 1984; Miller & Johnson-Laird, 1976) have previously proposed that spatial language and concepts reflect the way we typically interact with the world. The idea of a spatial framework extends these analyses toward a theory of how spatial concepts structure memory for environments. According to this model, subjects construct a spatial framework consisting of extensions of the three body axes, head/feet, front/back, and left/right, and associate objects to that framework. The framework of axes is used to retrieve objects and locations. The accessibility of an axis depends on characteristics of the body and the perceptual world and the posture of the body. Accessibility refers to the speed and accuracy with which spatial relations or objects can be retrieved from memory or identified in perception. Accessibility of directions associated with the body sides depends on the number and quality of cues to identification (Rigal, 1994).

Internal situation.—The first situation investigated was a person surrounded by objects on the six basic body sides: head, feet, right, left, front, and back. For an upright observer, objects oriented along the head/feet axis are most accessible because this axis is physically asymmetric and correlated with the up/down axis defined by gravity. Objects along the front/back axis are next most accessible because this axis is both physical and perceptually asymmetric, separating the world that can be seen and manipulated from the world that cannot be easily seen or manipulated but is not associated with any fixed environmental axis. The left/right axis is least accessible because it is perceptually symmetric and has relatively few physical asymmetries. In addition, because perceptual and motor/physical asymmetries so strongly favor front over back, the spatial framework model predicts faster response times to front than back. Franklin and Tversky (1990) and Bryant, *et al.* (1992) have observed this pattern of data when subjects learned scenes by reading narrative descriptions. Bryant, Tversky, and Lanca (submitted) observed the same pattern when subjects observed real scenes around themselves or viewed a model and responded from memory. Parts of the pattern have also been observed by others (Hintzman, O'Dell, & Arndt, 1981; Maki & Braine, 1985; Sholl, 1987).

External situation.—Another common perspective, the one investigated here, is the external perspective, wherein an array of objects is in front of the observer. Bryant, *et al.* (1992) studied narrative comprehension of such an array. The narratives described scenes as though the reader were outside the array looking at another person who faced the reader/observer (see Fig. 1). Objects were located above and below the person, and in front of, behind, left, and right of the person. In this case, "left" and "right" meant to the left and right from the observer's point of view (not to the other person's left and right sides), "above" and "below" referred to the gravitational up/down, "in front" referred to the object between the observer and the other person and, hence, closest to the observer, and "behind" referred to the object beyond the person (even though it was also to the observer's front). Readers responded to direction probes from the external point of view.

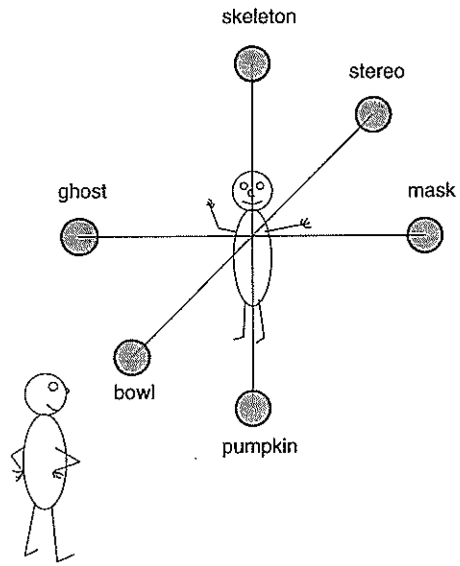

FIG. 1. Example of a scene depicted from an external perspective by Bryant, Tversky, and Franklin (1992, Exp. 4). The reader in that experiment occupied the perspective of the figure outside the array, looking at another character. In Exp. 1, this sort of scene was depicted by a physical model in which the character was represented by a doll. The subject was the figure outside the array looking at the front of the person.

For the external perspective, subjects construct spatial frameworks based on three orthogonal axes projected in front of the observer. The above/below axis corresponds to gravity and was predicted to be most accessible because it defines up/down in the environment. The front/behind axis projects out from the observer. It is not correlated with any fixed environmental axis, but it is the axis along which people are perceptually and behaviorally oriented. The left/right axis is defined by the observer's left and right and, as before, is least accessible. The pattern of response times predicted by the external spatial framework has been observed in memory for narratives (Bryant, *et al.*, 1992) and memory for real scenes (Bryant & Tversky, 1991). One difference that has been observed between the external and internal perspectives is that response times to objects in front of and behind an observer tend not to differ from an external perspective (Bryant, *et al.*, 1992).

The Present Experiments

Memory clearly relies on the use of spatial concepts, but does perception? We can answer this question by applying the spatial framework model and paradigm to an observational situation. This has already been done to determine whether people use spatial frameworks to locate objects from another person's perspective (Bryant, *et al.*, submitted). Subjects viewed arrays of objects around a doll in a model scene and located objects from the doll's point of view. Although the pattern of response times differed from that predicted by the spatial framework model, subjects did employ a conceptual representation. Response times did not display equiavailability, but, instead, subjects were faster to respond to objects located on the head/feet axis than on the front/back axis for all postures of the doll. Responses to left/right axis were always slowest. This is a different, but interpretable, conceptual representation (see Bryant, *et al.*, submitted). It reflects the importance of the observed person's intrinsic head/feet axis in defining the orientation of the spatial frame (see also, Logan, 1995).

It is not clear that a spatial framework would be used to locate objects from an external perspective. The major features structuring spatial concepts in the internal situation are the relative asymmetry of body axes and the person's posture. These features are less relevant for an external perspective. Further, an external perspective on a scene is similar to a viewed picture. This is exactly the analogy of the equiavailability hypothesis which states that spatial representations are like mental pictures and all locations are equally accessible. Viewers may have direct and equal access to all locations in a scene when they can respond to probes from their own perspective. The hypotheses of the spatial framework and equiavailability models are contrasted in Table 1.

TABLE 1
Hypotheses of the Spatial Framework Analysis (Physical Spaces) and the Equiavailability Model (Diagrammed Spaces)

Spatial Framework Analysis	Equiavailability Model
H1: RT(Above/Below) < RT(Front/Behind)	H4: RT(Above/Below) = RT(Front/Behind)
H2: RT(Above/Below) < RT(Left/Right)	H5: RT(Above/Below) = RT(Left/Right)
H3: RT(Front/Behind) < RT(Left/Right)	H6: RT(Front/Behind) = RT(Left/Right)

Nevertheless, when we consider the external perspective, at least one major feature structuring people's spatial concepts, the gravitational axis, is inherent in the physical space. Here, when a person views a scene and must locate objects in response to probes such as Above or Below, gravity is crucial to the observer's categorization of directions. Thus, an observer may consult a spatial framework to parse the scene mentally and locate objects in it. If so, this would be reflected in the response times to probes, which would be expected to conform to the external spatial framework. Consistent with this hypothesis are findings that subjects are faster to identify objects in Above/Below locations than other locations in two-dimensional displays (Logan, 1995; Maki & Braine, 1985).

In Exp. 1, subjects viewed a model containing a doll surrounded by objects on all sides. Subjects responded to direction probes from their own external perspective, identifying which objects were located above, below, in front of, behind, left, and right of the doll. The distances of objects to the doll were not varied, so directions refer to particular locations around the doll. Subjects' response times were recorded and compared to predictions. Because the task involves identifying locations from spatial concepts, it was predicted that subjects would construct external spatial frameworks and use them to interpret direction probes and identify objects at probed locations. Thus, response times should be fastest to Above and Below probes, slower to in Front of and Behind probes, and slowest to Left and Right probes.

Another way of dealing with space is by use of diagrams. This is an interesting case because diagrams are intermediate to language and physical environments. A diagram is representational, intended to convey spatial information about a place that is not physically present, just as is language. A diagram, however, is also a physical object having its own spatial properties, just as do real environments. The study of diagrams also has ecological justification because maps, sketches, pictures, and so on are commonly used to provide spatial information.

Exp. 2 examined whether people use spatial frameworks to guide the search for objects when they observe a diagram depicting a scene. One reason to expect they would is that the diagram conveys a scene that is supposed to exist in the gravitational frame (in fact, the diagrams were oriented in alignment with that frame). This should cue the use of the above/below spatial concepts as in observed physical scenes. Moreover, the type of scene conveyed in the current experiment is identical to that presented in the physical model of Exp. 1.

There are, however, reasons to expect that people will not use spatial frameworks for diagrams. First, although diagrams have spatial properties, those properties are different than those of real spaces. A diagram is two-dimensional and depth must be conveyed by indirect cues such as linear perspective. Second, diagrams are not in a fixed relation to gravity. Diagrams can be held vertically, but they are often laid flat so that neither of the two dimensions is aligned with gravity. Moreover, the top of the diagram can be held vertical or in line with the body, but it can also be rotated. Therefore, an observed diagram may be treated as an object for which gravity has no special status and hence no role in conceptualizing spatial relations within it. If a spatial framework is not used to guide search for objects in a diagram, there is no reason to predict faster access to Above and Below relations than to Front, Behind, Left, or Right.

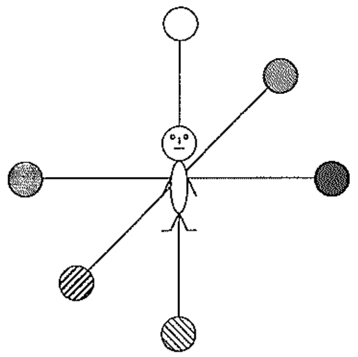

Fig. 2. The diagram used in Exp. 2. In the experimental displays, the circles around the human figure were solid red, blue, green, yellow, pink, or black. The diagonal line represents relations in depth.

An example of the experimental stimuli is shown in Fig. 2. The stimuli are poor perspective drawings; a simple diagonal line depicted relations in depth. This line is by no means an overpowering depth cue. Our use of it, however, was intentional. One could create drawings that better depicted depth by using various cues such as linear perspective. Our goal was first to look at diagrams that were as representational as possible before considering photographs or more artfully rendered diagrams that bear a closer spatial correspondence to real spaces. This provided a clearer contrast to model scenes. Also, because the spatial framework model is based on concepts of spatial relations, if spatial frameworks are not employed for symbolic diagrams, it is unlikely that they would be used for more realistic pictures.

METHOD

Experiment 1

Subjects.—Five male and seven female undergraduates of Northeastern University participated for credit in an introductory psychology class. All subjects in this and the second experiment were between the ages of 18 and 21 years. No individual participated in both experiments.

Materials.—The scenes were portrayed by a physical model. A "Homer Simpson" doll (28 cm tall) stood on a platform 28 cm high. The doll faced the subject at all times. Drawings of objects were hung from narrow wooden shafts at equal distances in front of, behind, and at the head, feet, left, and right of the doll. A set of 42 drawings of objects from Bryant, *et al.* (submitted) was used to represent scenes. The objects were drawn in black on a white background and were approximately 5 × 5 cm.

Location probes were presented by one channel of a stereotape recorder from a loudspeaker. One channel of the audiotape contained a sequence of probes for each scene. The probes were spoken by the experimenter, recorded and reordered on the tape. The second channel contained a series of tones that were coordinated with the auditory probes and controlled an electronic timing device. When a probe was presented, a tone started the electronic timer which measured response times accurately to 1 msec. The tones were not played from the loudspeaker. The timer was connected to a voice key. Subjects spoke their responses into a microphone connected to the voice key, which sent a signal to stop the timer.

Procedure.—For each scene, the experimenter placed six objects around the Homer doll, which faced the subject. The objects were randomly selected from the total set of 42 objects and randomly placed at locations in the model. The subject sat about two feet from the model which rested on a table. Subjects were seated at a slight angle to the model so that they could see the object located behind the doll. The model with doll and objects was left visible to the subject during the entire procedure. Subjects were instructed to look at the doll between probes.

Subjects completed 24 separate scenes, responding to six external location probes (Front, Behind, Above, Below, Left, or Right) for each. Subjects were instructed to interpret locations with respect to their own external perspective and not that of the doll. Thus, the probe "Front" meant "what object is in front of the person," "Left" meant "what object is to the left of the person," and so on. The six probes were separated by 4 sec. of silence. Subjects were instructed to, upon hearing a probe, say aloud the name of the object that was located at the probed location as quickly as possible, without sacrificing accuracy. The experimenter recorded the subject's response time and accuracy for each probe. Prior to the experimental trials, subjects completed six practice trials in which they received feedback about the accuracy of their responses. No feedback was given during experimental trials.

Design.—The independent variable was the probed location, which was varied within subject. The dependent variable was the response time subjects took to say the name of the object located at a probed direction. Direction probes within a scene were assigned one of six counterbalanced orders that assured that each probe appeared in each serial position an equal number of times across scenes.

Experiment 2

Subjects.—Eight male and eight female undergraduates of Northeastern University participated for credit in an introductory psychology class.

Materials.—Subjects viewed drawings of a schematic human figure inside a set of three axes, shown in Fig. 2. The human figure was 3.9 cm (1.5 in.) tall. The vertical and horizontal axes were 11.7 cm (4.5 in.) long, and the diagonal axis slightly shorter (approximately 11.05 cm or 4.25 in.). The diagonal line represented relations in depth and was always drawn from the lower left to the upper right of the screen. Braine, Schauble, Kugelmass, and Winter (1993) observed an early tendency in children to interpret objects to the left and lower in pictures as being nearer than objects to the right and higher. For example, when asked to place stickers on a page to indicate a near and far house, children tended to place houses on a diagonal to represent depth, this tendency increasing with age. Both American and Israeli children tended to place the near object to the left on the diagonal rather than to the right, indicating that the bias is not affected by direction of reading in the child's culture. This suggests that there is a strong bias, especially among American students, to interpret the left end-point of a diagonal as nearer than the right end-point. At the end of each axis was a colored target circle, 1.3 cm (0.5 in.) in diameter. Each target circle had a unique color, either red, blue, green, yellow, pink, or black. The target circles always occupied a position at the end of one of the axes, but the position of a given color was random from trial to trial. Thus, diagrams rarely had the exact same configuration of colors. There were a total of 144 diagrams (plus 12 practice diagrams). Direction probes consisted of the name of a direction relative to the subject's external perspective spoken over the computer's speaker.

Procedure.—Each subject sat before a MacIntosh IIsi computer with a 13-in. color monitor. The chair was adjusted in height so that the human figure in a diagram was at eye level and the subject's head was 57.2 cm (22 in.) from the screen. Subjects were told that they would view a series of 144 diagrams containing a person surrounded by six colored circles and were shown an example of the diagram. Subjects were further told that the configuration of colors around the figure would be random from trial to trial. Subjects were instructed that the diagonal axis represented an axis in depth and that they were to think of the lower end of the diagonal as projecting out from the computer screen toward them, and the higher end as projecting back into the screen away from them.

On each trial, a diagram appeared on the computer screen. After a 250-msec. delay, a verbal location probe (Front, Behind, Above, Below, Left, or Right) was spoken over the computer's speaker. Upon hearing a probe, subjects identified the color located at that direction. Subjects were instructed to interpret the probes from their own external perspective. When they had identified the color, subjects pressed the space bar and the diagram disappeared. Subjects were instructed to press the space bar only when they knew which color occupied the probed direction because the diagram would be removed once the space bar was pressed. They were also instructed to press the space bar as quickly as they could without sacrificing accuracy. The time subjects took to press the space bar was the critical response time. After subjects made this first response, the diagram was replaced by a screen with the single word prompt "Color?". When this prompt appeared, subjects indicated the correct color for the previous diagram by pressing one of six labelled keys occupying the middle portion of the middle row of the computer keyboard. This response served as an accuracy check and provided the second response time. Ideally, this response time should only be affected by the relative position of the response keys on the keyboard. After subjects made this response, the screen went blank for 250 msec. before the next diagram appeared.

During the 144 trials, the program paused after every 24 trials to allow the subject to rest. The subject pressed the space bar to continue the testing procedure. Prior to the testing phase, subjects completed 12 practice trials in which they received feedback about the accuracy of their response to the "Color?" prompt. Subjects received no feedback during the experimental trials.

Design.—The independent variable was probed location, which was varied within subject. The dependent variable was the time subjects took to decide which color was indicated by a probe. Subjects responded to an equal number (24) of probes for Front, Behind, Above, Below, Left, and Right in a random order.

RESULTS

Experiment 1

Of subjects' responses, 4.2% were lost, either because the subject made an inappropriate response, e.g., stuttering or making a noise that stopped the timer before saying the name of the object, or because of a malfunction of the timing device. Subjects made errors in response to 0.6% of the probes. Outliers, defined as response times greater than a subject's location cell mean plus two standard deviations, accounted for 2.2% of the data. Both errors and outliers were discarded from analysis because outliers may reflect extreme random variability or deviation from experimental procedure (see Kirk, 1982, p. 139). The remaining response times were collapsed across scenes to form subject means for analysis. Over-all mean response times are presented in Table 2.

Effect of location.—A one-factor analysis of variance with repeated measures indicated a significant effect of location ($F_{5,55}=10.59$, $MS_e=0.03$, $p<.01$), and response times conformed to the spatial framework hypotheses. Differences between subsets of location in this and the second experiment were tested by planned orthogonal contrasts. Responses to Above/Below locations were faster than those to Front/Behind locations ($F_{1,11}=6.10$, $MS_e=0.02$, $p<.02$) which were faster than those to Left/Right locations ($F_{1,11}=17.42$, $MS_e=0.05$, $p<.01$). A *post hoc* contrast of Front versus Behind indicated that response times to Front were significantly faster than those to Behind ($F_{1,11}=5.36$, $MS_e=0.02$, $p<.03$). If a Bonferroni adjustment is made to obtain a joint confidence interval for each of the 15 pairs of locations, this difference does not achieve significance. Nevertheless, a difference between Front and Behind stands in contrast to previous findings (Bryant, *et al.*, 1992).

Individual effects.—Data of individual subjects were generally consistent with the spatial framework model. To assess whether individual subjects tended to display the predicted pattern, subjects' response times were treated as the product of a random binomial process. There were six possible orders of response times to the three axes so that the pattern of response times predicted by the spatial framework model (Above/Below < Front/Behind < Left/Right) had a 1/6 probability of occurring by chance. The binomial probability indicated is the probability that the given number of subjects exhibited the predicted pattern by chance. Ten of 12 subjects exhibited the expected pattern (binomial $p<.001$). Ten subjects responded faster to locations in front than behind (binomial $p<.05$). Gender of subjects did not affect re-

TABLE 2

Mean Response Times (in Seconds) and Standard Deviations For External Perspective on a Model Scene (Exp. 1) and a Diagram of a Scene (Exp. 2)

Condition	Direction											
	Above		Below		Front		Behind		Left		Right	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Experiment 1												
Model Scene	0.891	.073	0.910	.109	0.913	.071	0.963	.079	1.016	.098	0.988	.122
Pairwise Means		0.900	.084			0.938	.073			1.002	.107	
Experiment 2												
Diagrammed Scene	1.209	.292	1.271	.341	1.461	.341	1.390	.350	1.229	.257	1.257	.337
Pairwise Means		1.240	.316			1.426	.342			1.243	.294	

sponse times ($F_{1,10}=0.29$, $MS_e=0.01$, ns) and did not interact with direction ($F_{5,50}=1.08$, $MS_e=0.003$, ns).

Experiment 2

A one-factor analysis of variance with repeated measures yielded no effect of location on the second response time ($F_{5,75}=1.07$, $MS_e=0.006$, ns), which indicates that subjects followed instructions not to press the space bar until they had identified the correct color. Only critical response times were used in subsequent analyses. Of these, 3.7% were errors and 4.2% were outliers, defined as in Exp. 1, which were discarded from analysis. The remaining critical response times were collapsed to form subject means for analysis. Over-all mean response times are presented in Table 2.

Effect of location.—A one-factor analysis of variance with repeated measures yielded a significant effect of location ($F_{5,75}=16.99$, $MS_e=0.161$, $p<.01$). Response times, however, did not conform to predictions of the spatial framework model. Instead, response times to Above/Below locations were essentially equal to those of Left/Right locations ($F_{1,15}=0.13$, ns), although response times for both were faster than those to Front/Behind locations (Above/Below vs Front/Behind, $F_{1,15}=58.44$, $MS_e=0.55$, $p<.01$; Left/Right vs Front/Behind, $F_{1,15}=56.74$, $MS_e=0.54$, $p<.01$).

Individual effects.—Individual subjects' data were consistent with the group's pattern. Fifteen of 16 subjects had slowest response times to Front/Behind locations (binomial $p<.001$), but only nine of 16 subjects responded faster to Above/Below locations than Left/Right locations (binomial $p>.05$). Gender of subjects did not affect response times ($F_{1,14}=0.25$, $MS_e=0.148$, ns) and did not interact with location ($F_{5,70}=0.62$, $MS_e=0.006$, ns).

Discussion

The pattern of response times in Exp. 1 conformed to the pattern predicted by the spatial framework model. They differed somewhat, however, from previous findings for the external perspective, in that subjects responded faster to objects in front than to objects behind (cf. Bryant, *et al.*, 1992). It is not possible that subjects adopted the internal perspective of the doll because this would have caused them to give incorrect responses consistently to Left and Right probes (which are reversed in the external and internal perspectives). It may be that the asymmetries of the Front/Behind axis are more salient in observed scenes than scenes described in narratives. This seems unlikely because the model was relatively small, and subjects were positioned in such a way as to ensure that the doll did not occlude the object behind it. Another possibility was suggested by informal postexperimental interviews with subjects. Although subjects were instructed to look at the doll between probes, many subjects reported that they sometimes looked at the object in front of the doll because it was closest to them and tended