DEVELOPMENTAL NEUROPSYCHOLOGY, *23*(1&2), 105–137

Objects, Motions, and Paths: Spatial Language in Children With Williams Syndrome

Barbara Landau
Johns Hopkins University

Andrea Zukowski
University of Maryland

The acquisition of spatial language is often assumed to be built upon an early-emerging system of nonlinguistic spatial knowledge. We tested this relationship by examining spatial language in children with Williams syndrome (WS), a rare genetic disorder that gives rise to severe nonlinguistic spatial deficits together with relatively spared language. Twelve children with WS, 12 normally developing mental-age matched children, and 12 normal adults described 80 videotaped motion events. Children with WS showed substantial control over key linguistic components of the motion event, including appropriate semantic and syntactic encoding of Figure and Ground objects, Manner of Motion, and Path. The expression of Path, although surprisingly spared, was more fragile among children with WS in contexts plausibly related to their nonlinguistic spatial deficit. The results show strong preservation of the formal aspects of spatial–linguistic knowledge and suggest that the nonlinguistic spatial deficits shown by children with WS have, at most, limited effects on their spatial language. These findings have implications for the relationship between spatial language and other aspects of spatial cognition.

One of our most fundamental capacities is the ability to talk about the objects and events around us. Even during early language learning, children take delight in commenting on objects and their motions through space. The privileged nature of the motion event in language learning stems, no doubt, from the salience and

---

Requests for reprints should be sent to Barbara Landau, Department of Cognitive Science, Krieger Hall, Johns Hopkins University, Baltimore, MD 21218. E-mail: landau@cogsci.jhu.edu interest that such events hold for young children. However, equally important is the fact that languages are well designed to capitalize on this salience, with universal means of encoding objects, their motions, and the paths along which they move. The early emergence of such aspects of language has traditionally been viewed as evidence that language builds on nonlinguistic representations: Because children can and do perceive and represent objects, motions, and paths, they naturally tend to express these notions linguistically. In fact, the character of children's spatial language has often been taken as a clue to the nature of their underlying nonlinguistic representation of space (Brown, 1973; Clark, 1973; Bowerman, 1996).

From this perspective, severe impairment in the child's nonlinguistic representation of space would predict corresponding impairments in spatial language. Must this necessarily be true? In this article, we address this question by examining the linguistic expression of motion events among children with Williams syndrome (WS)—a rare genetic defect which results in severe spatial deficits together with relatively spared language. The striking difference in profile between the two systems of knowledge—spatial cognition and language—raises the question of the extent to which spatial deficits in WS have an impact on the acquisition of spatial language. At the extremes lie two possibilities: Spatial language in children with WS might show severe deficits, like other aspects of their spatial cognition. Alternatively, their spatial language might be relatively spared, like other aspects of their language. Between these extremes lies the intriguing possibility that spatial language may be selectively impaired in ways that closely reflect the nature of the nonlinguistic spatial deficit. In this case, examining spatial language in children with WS should shed light on how nonlinguistic representations of space support spatial language and what consequences for spatial language follow from a deficit in nonlinguistic spatial representations. The results of such an investigation can, more generally, be brought to bear on considerations of the relationships between spatial language and spatial cognition.

BACKGROUND AND GENERAL ISSUES

WS is a neurodevelopmental disorder caused by a hemizygous microdeletion on the long arm of chromosome 7 (7q11.32). The syndrome gives rise to a variety of characteristics, including pathology of the heart and other internal organs, a characteristic facial profile (often referred to as *elfin facies*), and mild to moderate mental retardation. Of particular interest to cognitive scientists, however, is the unusual cognitive profile typical of individuals with WS: They show severe spatial deficits accompanied by surprisingly spared language. The unique developmental profiles of space and language naturally suggest the possibility that the two systems may be developmentally modular, emerging independent of each other (Bellugi, Bihrle, Neville, Doherty, & Jernigan, 1992).

The spatial deficits of individuals with WS have been documented in a range of studies, but the most widely cited evidence comes from tasks which require that people observe a spatial configuration and then reconstruct it, either by drawing a copy of a pictured object or array or by putting together a set of blocks to duplicate an existing multiblock spatial design. The spatial performance of individuals with WS is typically far inferior to normally developing children of the same chronological age (Bellugi et al. 1992; Mervis, Morris, Bertrand, & Robinson, 1999) and it is even inferior to normally developing children of the same mental age (Hoffman, Landau, & Pagani, in press; Mervis et al., 1999). For example, Bellugi et al. (1992) reported that individuals with WS performed in the bottom percentile of their age group in a standardized block construction task, and Mervis et al. (1999) reported the same. Importantly, the performance of these individuals in these construction tasks is qualitatively different from that shown by individuals with comparable retardation of different etiology. For example, when copying a multiblock design, children with WS tend to duplicate the local elements at the expense of the global form, but children of the same mental age with Down syndrome tend to do the reverse (Bellugi et al., 1992; see also Birhle, Bellugi, Delis, & Marks, 1989). The pattern of spatial deficit appears early in development, and although there is some developmental growth in the ability to solve spatial construction tasks, the severe deficit persists into adulthood (Mervis et al., 1999).

In contrast to this impairment in the spatial domain, individuals with WS typically show language capabilities that meet or exceed expectations based on mental age. The relative advantage of linguistic over nonlinguistic abilities appears quite early, within the first several years (Mervis & Bertrand, 1997), and thereafter, children with WS have language that is surprisingly fluent, with rich modulation of tone and expression (Bellugi et al., 1992). Despite this strength, recent research indicates that language in individuals with WS may not be entirely intact. For example, mastery of morphological rules and aspects of lexical learning may be impaired (Clahsen & Almazan-Hamilton, 1999; Karmiloff-Smith et al., 1997) and the semantics underlying certain lexical items in individuals with WS may not be as in conceptually rich as in normally developing children (Johnson & Carey, 1998). Nevertheless, vocabulary measures show performance generally above overall mental age (Bellugi et al., 1992) and, to the casual ear, the children's spontaneous vocabulary and overall language skills are strong (Bellugi, Wang, & Jernigan, 1994). It is safe to say that the contrast between their profound spatial deficit and their relatively spared language is striking.

What do these profiles predict for the acquisition of spatial language? Because spatial language sits at the intersection of spatial cognition and language, it affords us an unusual opportunity to understand the degree to which the two systems of knowledge emerge independently and/or interact with each other. In particular, it can help us to understand what aspects of spatial cognition might be crucial support for the acquisition of spatial language. At one extreme, if spatial language in WS is severely compromised, the details of its breakdown could provide insight about which aspects of spatial cognition are impaired. At the other extreme, if spatial language in WS is completely preserved, the details regarding preserved structure would provide insight about what aspects of spatial cognition might be intact. Each of these broad possibilities raises further questions. If spatial language is selectively impaired, does the nature of the impairment closely reflect the nature of the nonlinguistic spatial impairment? What do the selectively preserved aspects of spatial language suggest about mechanisms of acquisition?

To test these broad possibilities, we examined the language produced by children with WS when they were asked to describe on-going motion events. The motion events depicted a wide range of objects undergoing a variety of motions and moving along a variety of paths (see Materials for details). Motion events are of particular interest because languages universally encode them in terms of a small but specific set of components, which can plausibly be viewed as corresponding to the nonlinguistic components that guide our perception and understanding of such events. The question arises whether children with WS can represent these components and whether they can correctly encode them using language in order to describe the entire motion event.

SPATIAL COGNITION AND THE LINGUISTIC ENCODING OF THE MOTION EVENT

In an influential analysis, Talmy (1975) showed that the linguistic expression of motion events is universally encoded by a small set of key components, which are then assembled somewhat differently in different languages. Many linguists have suggested that these components may be reflections of the nonlinguistic representation of events (Fillmore, 1997; Gruber, 1976; Jackendoff, 1983; Langacker, 1987; Pustejovsky, 1991; Talmy, 1975).

The linguistic components represent the objects participating in the event, the types of motions that they undergo, and the paths along which the objects travel. Talmy uses the following example in English:

The bottle	floated	into	the cave.
Figure object	Motion + Manner	Path	Ground object

In Talmy's (1975) terms, the Figure object is that which normally undergoes motion, and in English, this is typically encoded as a noun phrase, in this case "the bottle." The Motion is represented by the verb in English, which may represent a simple motion such as "come," "go," or "move," but may also include a semantic element encoding the "manner of motion," in this case, resulting in the Motion + Manner verb "float." The Path along which the Figure object moves is usually encoded in English by a spatial preposition, as "into" in the example, and this is often combined with the Ground object, encoded in English as a noun phrase (in this case, "the cave"). Thus, the basic pattern in English encodes the Figure and Ground objects, Manner of Motion, and Path in separate terms, yielding what Talmy calls a "satellite" language, one in which the Path term is encoded separately from the Motion.

Although all languages encode the same set of components, they vary in how these components are packaged. For example, English possesses many Manner of Motion verbs, often packaging Manner together with Motion and expressing Path separately. In contrast, French and Spanish tend to package Path together with Motion (resulting in numerous verbs such as "exit" or "descend," which are relatively rare in English), and encode the Manner in a separate form, such as the adverb (e.g., La bottella *entra* en la cueva *flotando*/The bottle *moved into* the cave *floating*).

How might the linguistic expression of the motion event be affected by the spatial deficit characteristic of individuals with WS? Each component of the motion event might be affected somewhat differently because each encodes a different spatial element and because these elements differ somewhat in their linguistic requirements. This means that different patterns of preservation and sparing might follow from deficits in spatial cognition versus deficits in knowledge of language. We therefore consider the components separately, describing the requirements for appropriate conceptual/spatial and linguistic use of each. These are summarized in Table 1.

TABLE 1
Conceptual and Linguistic Components of the Motion Event

Component	*Nonlinguistic Representation*	*Linguistic Coding*
Figure object	Object kind (e.g., dog, woman, truck)	Noun phrase
	Spatial role (object that moves)	Theme/subject of sentence
Motion and Manner	Motion (and specific kind)	Verb (Manner of Motion)
Path	Path of travel	Preposition
	Bounded TO	TO prepositions
	Bounded FROM	FROM prepositions
	VIA	VIA prepositions
Ground object	Object kind (e.g., dog, woman, truck)	Noun phrase
	Spatial role (reference object)	Goal/object of the preposition
	Path-relevant properties	Semantic match to
	Container-type	IN/OUT prepositions
	Surface-type	ON/OFF prepositions

Note. The linguistic components listed here are appropriate to simple English sentences such as the ones described in the text. Most of the sentences produced by participants in our study were of this type.

Figure and Ground Objects

These require representation of the objects involved, their respective semantic/thematic roles in the event (i.e., Figure or Ground object), and correct assignment of each to its syntactic position. Figure and Ground objects are typically encoded in simple English sentences as the subject of the sentence and the object of the preposition, respectively.

The evidence on object representation in Williams syndrome is meager. However, the early emergence of object terms among children with WS does not appear to be seriously impaired (Mervis & Bertrand, 1997; Stevens & Karmiloff-Smith, 1997), and experimental evidence suggests no severe impairment in the object recognition system (see also Hoffman & Landau, 2000; Wang, Doherty, Rourke, & Bellugi, 1995). Furthermore, the early vocabulary of children with WS is comprehensive enough that one would not expect profound deficits in naming common objects. Beyond this, however, children with WS may or may not be able to understand the spatial/thematic roles of the Figure and Ground, respectively. If they have difficulties in understanding these roles or difficulty in mapping these roles into language, they might show problems in assigning the corresponding nouns to their semantic roles and to their proper syntactic positions. For example, correct assignment of Figure "the bottle" and Ground "the cave" to theme/sentential subject and goal/object of the preposition, respectively, requires accurate perception of which object serves each role (Figure/theme; Ground/goal) and how these are encoded syntactically. It is possible, therefore, that the children might name the objects correctly, but show errors in assigning the nouns to their proper thematic roles and syntactic positions.

Motion and Manner of Motion

These require that the child accurately perceive the motion that an object undergoes and encode it in the verb. To our knowledge, there is no evidence on knowledge of motion verbs among children with WS. However, there is some evidence regarding motion perception. In one study, individuals with WS were found to have abnormal motion perception, specifically showing raised thresholds for the detection of motion (Atkinson et al., 1997). In a different study, children with WS were found to have preserved perception of biological motion, showing the capacity to judge the direction of motion under a variety of noise conditions (Jordan, Reiss, Hoffman, & Landau, 2002). Neither study permits a straightforward prediction for whether children with WS should experience difficulty with the motion component of motion events because the stimuli and task requirements in studies of motion perception differ considerably from those in language tasks. What we can say, however, is that if children with WS have significant deficits in motion perception, this could result in difficulties naming specific motions, some of which require perception of direction (e.g., come vs. go/jump vs. fall). Furthermore, the encoding of specific Manners of Motion could be affected, since this requires perception of particular Manners and encoding by the proper Manner of Motion verb. It is possible, therefore, that children with WS might show impairment in the ability to use motion verbs appropriately, especially specific Manner of Motion verbs.

Path

Paths play a major role in the linguistic encoding of motion events (Jackendoff, 1983). In English, verbs of motion typically can accept a Path expression, although this is not obligatory. For example, verbs such as roll, spin, fly, walk, and move are grammatical with or without an accompanying specification of the Path (e.g., both "John flew" and "John flew to the moon" are grammatical). If the Path is expressed, this is accomplished using a "Path-function" term that encodes the Path itself, and in English, this is usually a spatial preposition. Some prepositions are intransitive, that is, they do not require that a Ground object be specified (e.g., both "John went up/down" and "John went up/down the street" are grammatical); others are transitive, requiring the presence of a noun phrase expressing the Ground object for grammaticality (e.g., "John went into the house" is grammatical, whereas *"John went into" is not). Thus, the structure of Path expressions requires accurately perceiving the Path, linguistically encoding it, and, in some cases, also encoding the Ground object, which must be placed in its proper syntactic position as object of the preposition.

Path expressions show further complexity, as they can be divided into three broad types, which code different kinds of spatial relationships (Jackendoff, 1983[1]; see Figure 1). In TO Paths, the Ground object is the goal, lying at the end of the path, for example, John ran *to* the *house*. In contrast, in FROM Paths, the Ground object is the source, lying at the beginning of the path, for example, John ran *from* the *house*. Both of these are Bounded Paths (i.e. they have definite origins or endpoints) and each can be encoded using a variety of prepositions (e.g., *on, to, in*, and *into* all encode TO Paths and *off, away/from*, and *out* all encode FROM Paths). In the third broad type, VIA Paths, the Ground object lies somewhere along the Path, but not at its beginning or end, for example, John went *by* the *house*). VIA paths can be encoded by terms such as *by, along, through*, or *over*. Thus, properly encoding the Path requires perceiving and representing the

---

[1] Jackendoff (1983) also discusses Directional Paths, which code Paths in which the Ground object does not lie at either beginning or end, but somewhere more distant along the Path, if it were to continue, for example, John went *toward* the house. *Toward* and *away from* encode this Path type; these two illustrative terms differ in polarity, just like the TO/FROM Path types discussed in the text.

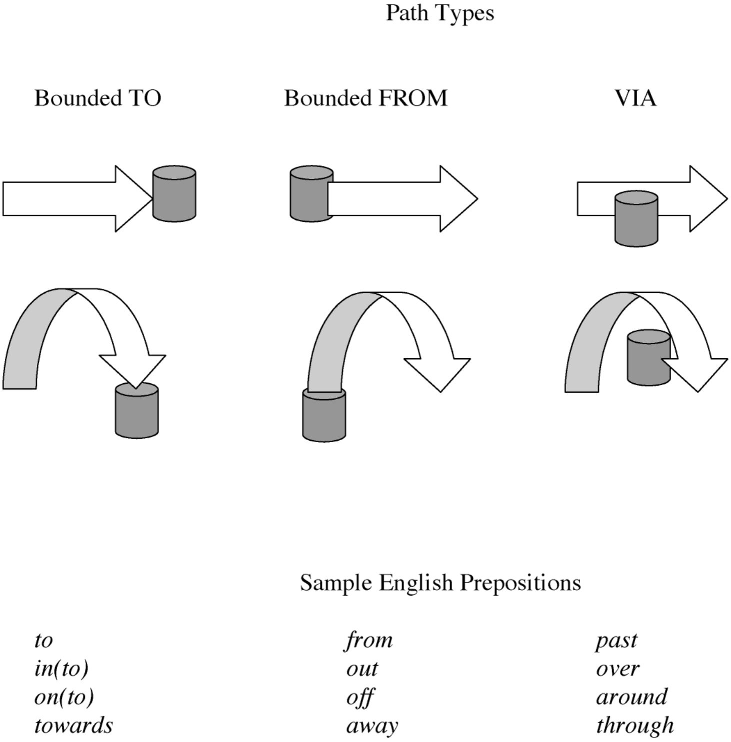
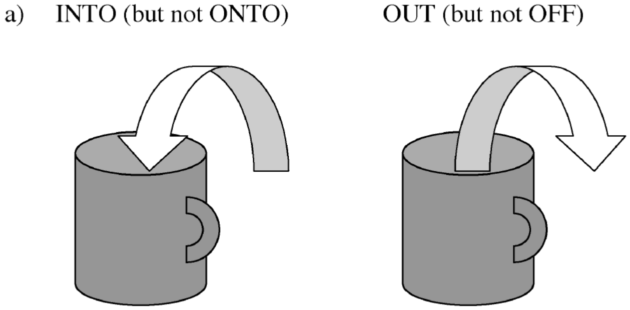


FIGURE 1 Three types of Paths that are distinguished in English by the sets of spatial prepositions that can encode them.

particular type of Path (Bounded TO, FROM, or VIA), each of which specifies a different spatial role for the Ground object. This representation of the Path must be used to select an appropriate spatial preposition.

A final complexity of Path expressions stems from the conceptual constraints that some prepositions place on their accompanying Ground objects (Herskovits, 1986; Jackendoff, 1983; Landau & Jackendoff, 1993; Talmy, 1983). We have already observed that encoding the Ground object requires representing the particular kind of object as a noun phrase, which is the object of the preposition. In addition, however, the meanings of some prepositions restrict the type of Ground object they can accept. Violations of these restrictions lead to oddities of expression in some cases, and in other cases to downright inaccuracies. Several prominent examples include the prepositions *in*(to), *out* (of), *on*(to), and *off* (of; see Figure 2). The first two terms are restricted to geometric types that, in some abstract sense, function like “containers”: Because the semantics of in and out



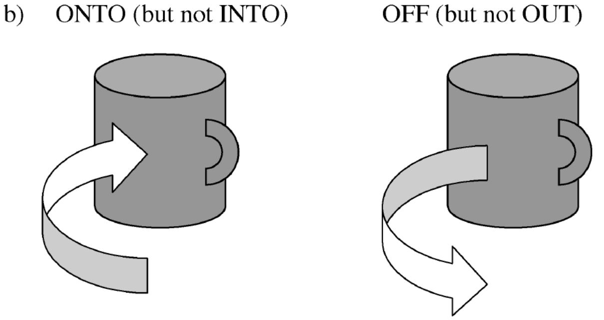


FIGURE 2 Certain spatial prepositions place geometric constraints on the Ground objects they can accept. See text for discussion.

refer, respectively, to the interior and exterior regions of containers, these prepositions can only occur with "container-type" Ground objects. Paths that lead from the inside to the outside of a container (or vice versa) must encode this "containerness" by using *into* (or *out of*) rather than *onto* (or *off of*). For example, given a bug that jumps from a table to the inside of a coffee cup, one can sensibly say, "The bug jumped *into* the coffee cup," but not "*onto*" the coffee cup. Similarly, because the semantics of on and off refer to the external surface and the exterior region of "surfaces," respectively, these prepositions can only occur with "surface-type" objects. Given a bug that flies from a table to the external surface of a cup, one can say "The bug jumped *onto* the cup," but not "*into*" the cup.

Properly encoding the Path therefore requires perceiving and representing the Path type, selecting an appropriate Path term, matching this Path term to an appropriate Ground object, and placing them in an appropriately structured prepositional phrase. Although, to our knowledge, nothing is known about the linguistic encoding of Paths by children with WS, it seems possible that this element of the motion event would be quite vulnerable to the effects of their nonlinguistic spatial deficit. Because Paths encode spatial relationships over time, and because the linguistic expression of Paths incorporates such rich spatial information, it seems quite possible that children with WS could show impairment in encoding different types of Path, selecting appropriate prepositions, and observing the selection restrictions that prepositions impose on their Ground objects.

In sum, the motion event encodes rich spatial information including the Figure object, its Motion and Manner-of-Motion, and the Path along which it travels with respect to a Ground object. Each of these components requires selection of an appropriate semantic element and placement of this element in the appropriate syntactic position. Spatial language in children with WS might be impaired overall or impaired selectively, reflecting breakdown in particular aspects of spatial representation. Conversely, spatial language in these children might be spared, either overall or selectively. In either case, the character of spatial language in WS is bound to shed light on which aspects of spatial representation are vulnerable and which are robust when they coexist with a severely impaired system of nonlinguistic spatial representation.

METHOD

To examine these issues, we elicited descriptions of simple motion events from children with WS and compared their performance to that of normally developing children matched for mental age as well as normal adults. The question was what pattern of sparing and deficit would be shown in this rich domain of spatial language.

Participants

Twelve children with WS (median age 9 years, 7 months [9:7], range 7:0–14:0) participated as well as 12 normally developing children who served as mental age matches (median age 5:0, range 3:6–6:9). Twelve undergraduates also participated to provide a ceiling against which the children's data could be compared. All groups were roughly balanced for gender. The children were given the Kaufman Brief Intelligence Test (Kaufman & Kaufman, 1990), which yields an overall IQ score as well as scores for two components, Verbal and Matrices. The Verbal component requires the child to name a series of objects portrayed by black and white line drawings. The Matrices component taps conceptual abilities, requiring judgments of which objects go together in pairs or form complete sets, but there are very few items that require spatial representation. With this measure, the children with WS are not penalized for their spatial deficit, and therefore their scores represent a fair measure of nonverbal (but nonspatial) intelligence. The children with WS were individually matched to controls, resulting in excellent matching for the component scores (*M* Verbal scores = 30.2 and 30.6, *SE*s = 2.2 and 1.9, ranges = 18–46 and 21–39, respectively; *M* Matrices scores = 17.3 and 17.6, *SE*s = 1.3 and 1.1, ranges = 10–24 and 13–21, respectively). The corresponding composite IQ scores were *M* = 77.3 (*SE* = 2.8, range 61–92) and 116.7 (*SE* = 2.8, range 102–139), respectively. The scores of the children with WS are similar to those of other groups studied by other researchers (e.g., Mervis et al., 1999).

On a variety of measures, the children with WS were severely impaired in their nonlinguistic spatial capacity, as would be expected. For example, their drawings of simple figures revealed the lack of spatial organization that is characteristic of people with WS (e.g., Hoffman & Landau, 2000). As part of a larger research program, the children were tested on the Pattern Construction subtest of the Differential Abilities Scale (Elliot, 1990). This requires the child to reconstruct a complex design composed of individual blocks, and is widely regarded as a hallmark task for diagnosing the spatial deficit in WS. Nine of the children with WS scored in the 1st percentile for their age, and the remaining three performed at the 4th, 8th, and 10th percentiles, respectively; the mean age equivalent for the group was 4 years, 2 months. These scores are similar to those reported in other studies of individuals with WS (Bellugi et al., 1992; Mervis et al., 1999) and indicate severely impaired spatial cognition. At the time of this study, only 4 of the normally developing controls were tested on the Pattern Construction test. They scored in the 60th percentile for their age (*SE* = 15.8), with a mean age equivalent of 6 years, 11 months. These scores are similar to those of our larger sample of normally developing controls (*n* = 9), who are also matched for mental age to the same children with WS, but are participating in other studies of spatial cognition in our lab. These children scored in the 51st percentile for their age (SE = 7.6), with a mean age equivalent of 6 years.

The children with WS were recruited with the assistance of the National Williams Syndrome Association and the A. I. DuPont Hospital for Children. They all lived within a 2.5-hr travel range of the University of Delaware. Normally developing control children were recruited from parent groups and preschools local to the University of Delaware. Undergraduates were students at the University of Delaware, who participated for class credit.

Design, Materials, and Procedure

Each participant viewed a set of 80 brief (5 sec) animated videoclips, one at a time, and described the simple motion events that occurred in them. This yielded a corpus of 2,880 sentences, which formed the basis for all analyses. The stimulus battery, the Verbs of Motion Production Test, was created and used by Supalla and Newport to evaluate mastery of the morphology of motion verbs in American Sign Language

(ASL; Newport, 1990; Singleton & Newport, in press; Supalla, 1982). The motion events were designed to elicit contrasts relevant in ASL, and many of these contrasts are also encoded in English, as discussed later; hence the battery was appropriate for use with English speakers. There was a broad range of motion events, which elicited a broad range of object, Motion, and Path terms in English (see Appendix for a complete list of events).

Participants were told that they were going to watch some short movies and that after each one they would be asked to tell the experimenter what happened. Our goal was to elicit sentences that included as many of the relevant components of the motion event as possible (Figure, Ground, Motion and Manner, Path). To maximize performance, and following Newport (1990), practice trials were given prior to showing the test events. The experimenter praised the sentences produced in these trials and, if necessary, encouraged more detail. For example, one practice event showed a chicken jumping off of a fence. If a child said, "It's a chicken," then the experimenter would say, "Right—and what happened?" Participants then generally produced more complete descriptions. Before moving to the next practice trials, the experimenter said, "Good—that's right, the chicken jumped off of the fence. Say it nice and complete, like that." Five practice trials were given just before the beginning of the task. During the test, children occasionally commented only on the existence of the Figure object; in these cases, they were prompted for more complete sentences as during the practice trials. Test sessions were videotaped and all of the responses were later transcribed for analysis.

The 80 events in the battery vary in the participating objects, the motions they undergo, and the paths along which they move. The objects include toy people, animals, vehicles, and common everyday objects. Forty of the scenes involve just a single moving object (the Figure object, which moves against an unmarked background) and the other 40 involve both a moving Figure object and a stationary Ground object. The events differ in Manner of Motion (e.g., rolling, flying, falling, jumping) and Path type. For the 40 events including a Ground object, Path type was determined by inspecting the videotaped event to ascertain the role of the Ground object. Of the 40 events, 12 involved Bounded TO Paths, 16 involved Bounded FROM Paths, and 12 involved VIA Paths. The Paths were executed in a variety of ways, including along a straight line, with a turn, or zigzagging. The categorization of Path types was confirmed by later analysis of the Path terms that were used by adults to describe each event. Path terms used by adults conformed perfectly to the initial categorizations of Path type.

RESULTS

The transcribed sentences were analyzed for quantitative and qualitative differences among the participant groups in the expression of the central components of the motion event. Participants in all three groups produced coherent, grammatical sentences and syntactically well-formed sentence fragments.

Figure Objects

Both quantitatively and qualitatively, the encoding of Figure objects was remarkably similar across the adults, normally developing children, and children with WS. Quantitatively, participants encoded the Figure object for almost every event (1% omission among children with WS, 2% among control children), and the Figure was almost always encoded as a subject noun phrase in full grammatical sentences. Of the 960 descriptions produced by each group (80 events × 12 participants), 480 involved a Ground object; of these, there were only 3 instances of reversal in syntactic assignment between Figure and Ground object, all produced by 2 children with WS. Among all participants, the preferred means for encoding the Figure was to use a specific noun. Across the 80 events, adults used a specific noun to name the Figure object 97% of the time (*SE* = 0.9), with the remaining 3% accounted for by more general noun phrases (e.g., "the thing"). The WS children used specific nouns 85% of the time (*SE* = 5.5), general noun phrases 5% of the time, and pronouns 6% of the time. The corresponding percentages for control children were 88% (*SE* = 2.9), 4%, and 6%, respectively.

The qualitative nature of the specific nouns used was also quite similar across the participant groups, reflecting considerable consensus in what the objects were and what they should be called. To quantify this, the modal adult response was listed for each of the events, and the children's responses were analyzed in terms of percentage that matched these adult-produced nouns. Across the 80 events, there were four different categories of Figure object: People, Animals, Vehicles, and Other types of object (*n*s = 8, 9, 17, 46, respectively). Across all categories, the adult modal responses accounted for 95% of their data; children with WS matched these 67% of the time (*SE* = 2.8), and control children 72% of the time (*SE* = 2.8). The remaining responses were semantically plausible alternatives to the modal adult responses. All Figure objects produced by the children were evaluated for semantic anomaly by two independent coders, blind to participant group. Semantic anomalies were defined as terms that incorrectly named the Figure in the context of each event, and only items scored as anomalies by both coders were further considered. Out of the 960 descriptions produced by each group, anomalous Figure objects were produced less than 1% of the time in either group.

The percentage of children's matches to the adult modal term for each category of Figure object were entered into a 2 (Group) × 4 (Category of Figure object) analysis of variance (ANOVA), resulting in a main effect of Figure object Category, $F(3, 66) = 9.07$, $p < .01$, and an interaction between Group and Figure Category, $F(3, 66) = 3.13$, $p < .05$. The control children matched the adult responses more frequently than did the children with WS on all Figure types except People, where the reverse was true, but none of the pairwise comparisons between controls and children with WS reached significance (Tukey's HSD = 21, critical *p* = .05, in this and all further comparisons). In sum, Figure objects were encoded at ceiling levels by all groups, and responses were syntactically well-formed and semantically coherent.

Ground Objects

Across the 40 events in which a specific Ground object was present, adults produced a pertinent term 99% of the time; these were almost always as object of the preposition. Of these, 93% were specific nouns (*SE* = 1.5) and 4% were general noun phrases. Thus, for adults, the Ground object was considered to be an obligatory element of their descriptions. In contrast, both groups of children omitted the Ground object relatively frequently, with controls omitting it approximately12% of the time and WS children 26% of the time (*SE*s = 2.0, 3.5), a difference considered at more length later. When they included the Ground object, control children produced specific nouns 77% of the time (*SE* = 4.4), and general noun phrases 6% of the time; children with WS produced specific nouns 60% of the time (*SE* = 6.5) and general noun phrases 4% of the time. The remaining responses fell into the following categories. Ground objects were coded by pronouns 1% of the time (each group of children) and were supplied by the experimenter 1% of the time (WS only). The remaining 4% of the controls and 8% of the responses from WS children were somewhat ambiguous with respect to whether they coded the Ground object, as they appeared to code it implicitly by using impact verbs such as crash (whose semantics assumes a goal, 1.4% controls, 3% WS) or specific Path terms such as off or out for events where the Ground object was a surface or container, respectively (thus suggesting a specific kind of Ground, 2.6% controls, 5% WS). Two different sets of analyses were conducted, one including and one excluding these ambiguous items in the category of Omissions. The results did not differ. Therefore, the results reported here used the more conservative estimate of Omissions; that is, without these ambiguous items.

Considering the children's specific nouns against the adults' modally produced Ground objects for each event, control children matched the adult choices 62% of the time (*SE* = 3.0), and children with WS matched 68% of the time (*SE* = 2.9). The rest of the nouns were plausible alternatives to the adult choice. Using the same criteria for semantic anomaly as for Figure objects, we found that anomalous Ground objects were produced less than 1% of the time by either group of children.

Inspection of the contexts of the Ground object omissions revealed that certain types of events—specifically, those involving certain types of Paths—were especially vulnerable (see Table 2). Recall that there were 12 Bounded TO Paths, 16 Bounded FROM Paths, and 12 VIA paths. A 2 (Group) × 3 (Path type) ANOVA was conducted on the percentage of omissions made by children over different

TABLE 2
Mean Percentages and Standard Error of Ground Object Omissions as a Function of Path Type in the 40 Figure–Ground Events

	Adults		*Controls*		*Williams Syndrome Group*	
Path Type	*M*	*SE*	*M*	*SE*	*M*	*SE*
Bounded TO[a]	0.0	0.0	6.9	1.7	14.6	4.1
Bounded FROM[b]	1.0	0.7	12.0	3.8	35.9	7.2
Via[c]	2.1	1.5	16.0	4.2	22.9	5.1
Total[d]	1.0		11.7		25.6	

[a]$n = 12$. [b]$n = 16$. [c]$n = 12$. [d]$n = 40$.

Path types. The results showed a main effect of Group, $F(1, 22) = 5.5$, $p < .05$, and Path type, $F(2, 44) = 8.9$, $p < .01$, and an interaction between the two, $F(4, 44) = 4.6$, $p = .01$. Children with WS omitted more Ground objects overall than control children. Moreover, the omissions by the children with WS were reliably related to Path type. Post-hoc comparisons revealed no reliable differences across Path type for the control children, but the children with WS omitted reliably more Ground objects in events with FROM Paths than events with either TO or VIA Paths (critical difference = 13). We return to this fact when we discuss the results for Path terms.

Motions

As with the naming of Figure and Ground objects, there are many options for naming the motion: Each could be encoded using a simple motion verb such as go or move; most could also be encoded using more specific verbs that express Manner of Motion, such as jump or fly. Some of the events could be plausibly described without using a motion verb at all. Nevertheless, all groups of participants encoded most events using Motion verbs (adults 92%, control children 89%, and WS children 89%, *SE*s = 1.4, 1.7, and 1.7, respectively), and these were produced in syntactically correct contexts. The remaining nonmotion verbs will not be considered further in any analyses.

A first analysis was conducted to determine whether, across all 80 scenes, there were quantitative differences across the groups in the use of simple verbs of motion, compared to more specific ones. All verbs were classified as Simple (including the verbs go*,* come, and move) or Specific (including all remaining verbs, most of which were Manner of Motion). Adults used Specific Motion verbs 72% of the time, whereas controls did so 64% of the time and children with WS 57% of the time (*SE*s = 2.5, 3.0, and 5.4, respectively). An ANOVA was conducted on the proportion of Specific Motion verbs used by different participant groups. There was a reliable effect of Group, $F(2, 33) = 3.5$, $p < .05$; post-hoc tests showed a reliable difference only between adults and children with WS (critical difference = 13.4). Thus children with WS used fewer Specific Motion verbs than adults, but were not reliably different from their mental age matches.

Remarkably, the Specific verbs used by the participants were very similar. Table 3 shows the 12 most frequent Specific verbs of motion and their relative frequency. The top 7 verbs—all Manner of Motion verbs—were identical and are ranked identically across the three groups. These verbs account for approximately 71% of the uses of adults and WS children and 78% of the uses of the control children (*SE*s = 3.2, 2.8, and 2.5, respectively). The remaining verbs include additional Manner of Motion verbs and Path verbs (e.g., turn, zigzag), and bring the total up to roughly 84% for adults, 86% for control children, and 88% for children with WS (*SE*s = 2.2, 2.2, and 2.5, respectively). Verbs were coded for semantic anomaly, as with Figure and Ground objects. Control children produced anomalous verbs 1% of the time and children with WS did so 3% of the time.

Given the inherent ambiguity of any motion event, we find it remarkable that the three groups of participants converged so closely on their choice of motion verbs to describe the main motion. Although the children with WS did use simple verbs of motion reliably more often than adults, the absolute difference was not large.

Paths

The three groups of participants produced broad corpora of Path terms, which overlapped each other considerably. The complete corpus produced over the 80 events by each group is shown in Table 4. The high degree of overlap indicates that the bulk of

TABLE 3
Twelve Most Frequent Specific Verbs of Motion

Adults		*Controls*		*Williams Syndrome Group*	
Verb	*%*	*Verb*	*%*	*Verb*	*%*
Fall	26.6	Fall	31.0	Fall	28.1
Jump	14.7	Jump	17.2	Jump	12.7
Fly	9.1	Fly	11.3	Fly	11.5
Hop	7.1	Hop	7.5	Hop	5.6
Walk	5.6	Walk	4.5	Walk	7.3
Roll	4.4	Roll	5.5	Roll	4.2
Drive	4.2	Drive	1.5	Drive	1.9
Slide	3.8	Slide	1.9	Flip	4.4
Make a turn	2.6	Run	1.4	Turn	3.8
Spin	1.5	Go in “L”	1.5	Zigzag	3.5
Back up	2.3	Ride	1.4	Run	2.9
Bounce	1.8	Bump	1.4	Bounce	1.9
Totals	83.7		86.1		87.9

TABLE 4
Percentage Production of All Path Terms over All 80 Events

Terms	*Adults*	*Controls*	*Williams Syndrome Group*
Simple path terms			
Across	22.2	5.3	2.9
Against	0.1	0.2	—
Along	0.8	0.2	—
Around	3.1	2.5	2.5
At	0.3	0.7	—
Away	—	3.6	2.7
Back	0.2	0.7	1.7
Backwards	2.7	3.3	1.5
Behind	0.7	0.7	0.2
Beside	—	0.2	—
By	1.3	0.5	0.6
Down	5.2	8.3	10.1
Downhill	0.3	—	—
Downward	0.1	—	—
Forwards	—	0.4	—
From	1.2	0.8	0.4
In	1.6	5.1	4.8
Inside	0.2	—	—
Into	3	1	3.4
Near	—	0.5	—
Off	13.7	18	15.2
On	3.8	9.4	5.3
Onto	1.2	1.3	0.8
Out	3.9	3.8	1.7
Over	9	10.6	26.9
Past	1.7	3	0.8
Through	6.7	6.3	2.3
To	3.1	2.6	5
Toward(s)	1.7	—	—
Under	0.1	0.2	—
Up	2.5	3.6	2.5
Uphill	0.3	—	—
Other simple	—	—	0.4
Around and Around	—	0.7	0.8
Away from	2.3	1.2	0.8
Back of/back to	—	0.3	0.2
Close to	—	0.2	—
Down from/down off	0.1	0.2	0.4
From x to y	1.2	0.7	—
In back of/in front of	0.2	0.4	0.2

(*continued*)

TABLE 4 (*Continued*)

Terms	*Adults*	*Controls*	*Williams Syndrome Group*
In front of	—	0.2	—
In and out	—	0.2	0.8
In his way	—	0.5	—
In the middle	—	—	0.2
In through	—	—	0.2
Left to right	0.1	—	—
Next to	—	0.2	0.2
On left side of	0.1	—	—
On over	—	—	0.2
On top of	2	0.2	0.4
Out around	—	—	0.2
Over and over	—	—	1.3
Over to	0.6	0.2	1.5
Over towards	0.1	—	—
Perpendicular to	0.1	—	—
Right in front	—	—	0.2
Up and down	0.1	2.8	1.1
Up to	2	0.2	0.2

the Path terms available to adults are also part of the vocabulary of both children with WS and their mental-age matches. However, there were differences across groups in both the tendency to encode Path for different kinds of events and in the qualitative nature of the Path terms used.

To quantify these differences, Path terms were coded in terms of four categories: Correct terms, Incorrect terms, Ambiguous Intransitives (terms *over, around, away*, and *back/backwards* when used intransitively), and Omissions. Correct terms were those that were acceptable descriptions of the Path in adult usage. These included terms that were the same as the term used modally by the adults as well as other terms that accurately represented the path, though not with the modal adult term. Incorrect terms were those that were not accurate representations of the path (e.g., "jumped *over*" to express the motion of a cup "jumping" *onto* a frog's head). Ambiguous intransitives were included as a separate category because the children sometimes used these terms in a fashion that made it unclear whether they were encoding a distinct path, for example, "He flew over" or "It hopped around." Omissions were responses that included no Path term at all. Coding of all responses was done by the second author. In addition, 20% of the corpus of sentences coded as "Other Correct" or "Incorrect" (i.e., those that required a subjective judgment for coding) were also coded by Barbara Landau to compute reliability, which was above 90%.

Initial inspection of the Path terms revealed that events portraying motion of a Figure object alone (n = 40) elicited a very different pattern among both adults and children than Figure–Ground events ($n = 40$). In particular, the Figure-only events tended to elicit a very broad range of Path terms. This is understandable: Because there is no specific Ground object, speakers have free choice as to whether they describe the path as moving TO some point or moving FROM some point. This means that, for these events, a wide variety of Path terms could be used sensibly, for example, X moved FROM the left, X moved TO the right, and X moved ACROSS the screen. In contrast, the Figure–Ground object events tended to elicit a much more constrained range of Path terms, which varied systematically across the different Path types (TO, FROM, VIA). Therefore, the Figure–only events were analyzed separately from the Figure-Ground events.

Figure-Only Events

Table 5 presents the results for 34 of the 40 Figure-only events. These portrayed an object moving either across the ground (grass, floor, etc.), through the air, or up/down a hill. The remaining 6 events portrayed a single object falling over, and all groups of participants described this correctly with either "fall *over/down*" or "fall" (adults, 86%, 14%, *SE*s = 7.1, 7.1; control children, 69%, 31%, *SE*s = 11.8, 11.8; children with WS 57%, 33%, *SE*s = 9.7, 8.9). For the 34 events summarized in Table 5, adults encoded the Path roughly 87% of the time (*SE* = 3.8), including the background as Ground object, saying, for example, "The bunny hopped downhill" or "The knife moved across the screen." In contrast, both controls and children with WS tended to omit mention of the Path in these events, producing a Path term only 37% and 38% of the time (*SE*s = 7.6 and 4.9), respectively. Note that describing these events without a Path term is perfectly grammatical, as when one reports only the Manner of Motion of the Figure object (e.g., "The bunny was hopping" or "The knife moved").

The children's uses of Path terms were often Correct (25.2% controls, 15.9% WS over all 40 events), with modest proportions of Incorrect terms (3.6% controls, 7.3% WS) and Ambiguous Intransitives (8.4%, 14.3%, respectively). Adults'

TABLE 5
Mean Percentges and Standard Errors of Classified Path Expressions in 34 Figure-Only Events

	Percent Correct		*Percent Incorrect*		*Percent Ambiguous Intransitives*		*Percent Omissions*	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Adults	80.0	6.2	0.5	0.3	6.8	0.4	12.7	3.9
Controls	25.2	8.3	3.6	1.0	8.4	2.3	62.8	7.6
Williams syndrome group	15.9	3.6	7.3	2.7	14.3	3.6	62.4	4.9

modal term for these events was *across* (52% of all terms used, *SE* = 7.9). The most frequently produced term for control children was *up* or *up and down* (32%, *SE* = 5.1). The modal term for the children with WS was *over* (24%, *SE* = 8.8), one of the Ambiguous Intransitives (e.g., "The knife went *over*" to describe a knife moving along the ground). The percentages of the children's responses were entered into a 2 (Group) × 2 (Response type: Correct vs. Incorrect and Ambiguous Intransitive) ANOVA which showed no reliable main effects, *F*(1, 22) = 1.1, *ns*, or interactions, *F*(1, 22) = 2.4, *p* = .13. Thus although the children with WS produced fewer correct responses than controls, the difference was not reliable.

In sum, for events portraying the Figure object moving alone with respect to a background, children in both groups omitted the Path term frequently, but their remaining responses were roughly comparable.

Figure and Ground Object Events

These events elicited a constrained set of Path terms among all participant groups, and the terms corresponded quite well to the three Path types that were portrayed: Bounded TO, Bounded FROM, and VIA. The top five terms produced by the different participant groups for each of these event types are shown in Table 6.

Inspection of the table reveals several notable facts. First, the Path terms were well suited to the nature of the Path portrayed in the videos, suggesting that all participant groups generally organized their corpus of Path words in terms of these distinct Path types. Second, there was considerable overlap across participant groups in the Path terms produced for events corresponding to the different Path types. Nevertheless, there were also several apparent differences.

For Bounded TO paths, participants in all three groups used terms describing motion to a surface (*on/onto/on top of*), to a container (*in/into*), and to a point (*to/up to*). There were no violations of the semantic restrictions for the two sets of terms, that is, no uses of *in* to describe motion to a surface or *on* for motion to a container. In addition to these terms, adults alone used the term *towards* (indicating motion that is not bounded), control children alone used *backwards* (to describe the orientation of the Figure as it approached the Ground), and children with WS alone used *over*. The latter was produced frequently as the sole Path term by WS children (14.6% of the total terms in TO paths, WS = 5.9). Checking the entire corpus for the Bounded TO Paths, we found that this term was never produced as the sole Path term by either the control children or the adults, who only used the term occasionally in combination with *to* or *towards*, yielding TO Path compound expressions *over to/over towards* (3.9% and 1.1% for adults and controls, respectively). A number of the WS children's uses of *over* were semantically anomalous, for example, describing a tree moving onto the top surface of a block with, "The tree jumped over the block," or a cup moving onto a frog's head as,

TABLE 6
Mean Percentage Production of Five Most Frequent Path Terms for the Three Event Types

	Adults		*Controls*		*Williams Syndrome Group*	
Path Type	*Term*	*%*	*Term*	*%*	*Term*	*%*
Bounded TO[a]	Into	20.5	On	31.9	On	23.3
	On top of	13.4	In	16.5	Over	14.6
	Up to	9.4	To	11.0	To	13.6
	Toward(s)	9.4	Onto	8.8	In	13.6
	On	9.4	Backwards	5.5	Into	12.6
Bounded FROM[b]	Off	63.1	Off	55.9	Off	39.7
	Out	18.2	Out	10.6	Over	17.3
	Away from	9.6	Down	6.4	Down	16.0
	From	4.3	Over	5.3	Out	5.1
	Through	1.1	Away from	3.7	Up	2.6
					Through	2.6
					Backwards	2.6
					Back	2.6
VIA[c]	Through	23.3	Over	26.6	Over	46.7
	Over	22.0	Through	21.9	Around	5.8
	Around	10.7	Past	13.3	Through	5.0
	Past	10.0	Around	7.8	To	4.2
	Backwards	8.7	On	5.5	Past	3.3
					Off	3.3
					Into	3.3
					Back	3.3

[a]$n = 12$ events. [b]$n = 16$ events. [c]$n = 12$ events.

"The cup went over the frog." Such errors may arise from children's use of the term *over* to represent the static final location of the Figure ("over" the block or frog's head), comparable to *above* or *on*.

For Bounded FROM paths, participants in all groups used terms describing motion from a surface (*off*), container (*out*), and point (*away from/from*). There were no violations of the semantic restrictions for these terms (e.g., using *off* for containers or *out* for surfaces). Control children and children with WS also used a simple directional term (*down*) to describe downward motion away from the Ground object. The term *over* was again used frequently by children with WS (17.7% of terms in FROM paths, $SE = 5.1$) and occasionally by control children (5.3%, $SE = 2.5$). Children with WS sometimes used it as a general directional term (e.g., "The lady went over") and other times in anomalous fashion (e.g. "The block jumped over the other block" to describe one brick "jumping" down off of another). Several control children also used it in this way.

TABLE 7
Mean Percentages and Standard Errors of Classified Path Expressions for 40 Figure–Ground Events

Path Type	*Participant Group*	*Percent Correct*		*Percent Incorrect*		*Percent Ambiguous Intransitives*		*Percent Omissions*	
		M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Bounded TO events	Adults	99.1	0.9	0.9	0.9	0.0	—	0.0	—
	Controls	80.3	3.8	6.9	2.4	5.3	1.9	7.4	2.9
	WS	66.7	8.0	17.2	5.1	4.6	2.9	11.4	4.3
Bounded FROM events	Adults	99.0	0.7	0.5	0.5	0.5	0.5	0.0	—
	Controls	78.0	5.6	11.6	3.3	5.3	2.2	5.1	3.8
	WS	55.7	6.0	16.2	4.0	11.6	2.5	16.6	6.9
VIA events	Adults	97.7	1.2	1.6	1.1	0.7	.7	0.0	—
	Controls	76.9	4.9	9.4	2.7	1.5	1.0	12.3	2.9
	WS	48.0	6.9	19.8	6.2	12.5	3.9	19.7	7.4
All Figure–Ground events	Adults	98.6	1.0	0.4	0.0				
	Controls	78.4	9.3	4.0	8.3				
	WS	56.8	17.7	9.6	15.9				

Note. WS = Williams syndrome.

For VIA paths, participants in all groups used *over, through, around*, and *past* to describe motion with respect to the Ground object. The only obvious difference in distribution of the terms was the very high frequency of use of *over* by children with WS and relatively low use of *through*. Many of the WS children's uses of *over* occurred in contexts in which the control children and adults used *through*, cases where one object threaded itself through a tube like Ground object.

In sum, the top choices of Path terms were organized similarly across the three groups, suggesting generally appropriate choice of terms for different Path types among both controls and children with WS. However, there were also several indications that the children with WS used certain Path terms, in particular, *over*, in contexts that resulted in semantically anomalous encoding of the Path.

These patterns were quantified by coding all descriptions in terms of correct, incorrect, ambiguous intransitives, and omissions. The data are presented in Table 7 by Path type (Bounded TO, FROM, and VIA). A first analysis was conducted on the percentage of correct responses by the children (*M*s = 78% and 56% for the controls and the children with WS, respectively). A 2 (Group) × 3 (Path type) ANOVA revealed reliable main effects of Group, $F(1, 22) = 10.9$, $p < .05$, and Path type, $F(2, 44) = 3.73$, $p < .05$. Control children produced reliably more correct terms than children with WS over all Path types, and across groups, reliably more correct terms were produced for the Bounded TO Paths than for either the Bounded FROM or VIA paths (Tukey's HSD = 10.2). Planned comparisons revealed that the controls did not differ in the proportion of correct terms across the three Path types (all *t*s < 2.0, *df*s = 44, *ns*). However, the children with WS produced reliably more correct terms for Bounded TO paths than for either Bounded FROM or VIA paths (*t*s = 2.4 and 3.17, respectively; *df*s = 44, $p < .05$). Moreover, control children produced reliably more correct terms than children with WS for every Path type (all *t*s > 2.0, *df*s = 44, $p < .05$). A second analysis considered the proportions of these correct terms that also matched the modal term produced by adults for each event, and this revealed the same effects.[2]

The remaining categories include incorrect Path terms, ambiguous intransitives (*over, around, away*, and *back/backwards*), and omissions. Incorrect Path terms by themselves indicate an error in linguistic encoding of the Path type portrayed. A 2 (Group) × 3 (Path type) ANOVA on these data revealed only a marginal effect of Group, $F(1, 22) = 3.6$, $p = .07$; children with WS produced more errors. Both of the remaining categories reflect the child's tendency not to code a specific Path: Omissions are cases where no specific Path has been encoded, and ambiguous intransitives are Path terms that do not clearly express a particular Path. These two categories were collapsed, and the data were entered into a 2 (Group) × 3 (Path type) ANOVA, resulting in a main effect of Group, $F(1, 22) = 4.3$, $p < .05$, and of Path type, $F(2, 44) = 2.99$, $p = .06$, and an interaction of the two, $F(2, 44) = 2.96$, $p = .06$. Children with WS produced more of these responses than control children, and VIA Paths elicited more of this response type than Bounded TO Paths (Tukey's HSD = 8.5). Planned comparisons were used to examine the interaction of Group and Path type. Controls showed no reliable differences in these responses over the three different Path types, whereas children with WS showed reliably more of these responses for Bounded FROM and VIA events than Bounded TO events, *t*s = 2.43, 3.25, *df*s = 44, $p < .05$.

To summarize, the children with WS tended to produce fewer correct terms than control children and more combined omissions and ambiguous intransitives than controls. Both of these patterns interacted with Path type: The children with WS performed better when describing Bounded TO Paths than either Bounded FROM or VIA Paths, whereas the control children showed no such effects. This effect of Path type is reminiscent of the pattern seen for Ground objects: There, children with WS omitted reliably more Ground objects than controls, but their omissions were less frequent for Bounded TO Paths than Bounded FROM Paths, with VIA Paths falling in between the two other Path types.

---

[2] Like the first analysis, there were reliable main effects of Group, $F(1, 22) = 18.14$, $p < .05$, and Path type, $F(2, 44) = 7.48$, $p < .05$. Planned comparisons for these data again showed that the children with WS produced reliably more best matches for Bounded TO Path types than either FROM or VIA Path types (*t*s = 2.2 and 3.76, respectively, *df*s = 44, $p < .05$). In addition, comparisons showed that control children produced reliably more best matches for FROM Path types than VIA path types ($t = 2.17$, $df = 44$, $p < .05$).

DISCUSSION

The evidence shows that children with WS control much of the linguistic structure required for expressing motion events. When considering the rich requirements for producing semantically coherent descriptions of such events, we find it remarkable that such competence can be found in the context of profoundly impaired nonlinguistic spatial cognition. However, the children also show some clear limitations in their linguistic encoding of the motion event. We speculate that these limitations are tied to their nonlinguistic spatial deficit and reflect the difficulty of representing spatial information about motion events over time. This combination of strengths and limitation can shed light on the interaction of spatial language with nonlinguistic spatial cognition: Although the children with WS have semantic and syntactic knowledge of the components of the motion event, they cannot always use this knowledge to describe visually perceived events.

Preservation of spatial–linguistic structure was observed in several domains. First, the encoding of Figure and Ground objects as named object kinds was preserved, as was the representation of their spatial roles, seen through their syntactic encoding as subject and object of the preposition, respectively. Across the 480 descriptions of events involving both Figure and Ground objects, the children produced only three syntactic reversals of Figure and Ground objects. Thus the object kinds represented by the Figure and Ground, the basic spatial roles played by the two objects, and their mapping onto syntactic position all appear to be intact. The accurate naming of the objects by children with WS suggests that their representation of objects for the purposes of naming may not be impaired, consistent with evidence from Wang et al. (1995) and Hoffman and Landau (2000). In addition, the accurate assignment of object names to Figure and Ground roles suggests that the children's understanding of the relative spatial roles of the two objects is preserved. Finally, the correct mapping of these roles into syntactic position suggests preservation of the syntactic–semantic mapping between the spatial representation of the event and the corresponding linguistic structures.

Children also encoded the Figure object's motion properly, including the specific Manner of Motion portrayed. We note again that it would be perfectly possible for children to encode any of the portrayed motions in terms of spatially simpler verbs that indicate only motion, for example, *go, move*, etc. The accurate mapping of the portrayed motion indicates, we believe, intact perception of the different manners of motion as they were portrayed in our stimuli as well as intact ability to encode these with the appropriate verbs.

This conclusion does not necessarily suggest that all aspects of motion perception are intact in children with WS. For example, the results from Atkinson et al. (1997) suggest that children with WS are impaired in some aspects of motion perception. Atkinson et al. asked children with WS (ages 4–14 years) to detect and report the direction of common motion of a set of dots when it was embedded in background noise made up of dots moving in the opposite direction to the target set. Compared to normal participants of roughly the same chronological age, children with WS showed a higher threshold for detection, suggesting more disruption of the ability to perceive directional motion as noise increased. Our stimuli were clearly suprathreshold, and so it would be possible for our WS participants to perceive these stimuli sufficiently well to allow linguistic encoding, even if more subtle aspects of their motion perception are impaired. Key questions are what aspects of motion perception and what degree of sparing are necessary for the accurate linguistic encoding of motion events. One intriguing and relevant finding is from a recent study by Jordan et al. (2002), who found that under a range of conditions, children with WS are unimpaired in detecting and reporting both direction and kind of biological motion (e.g., jumping vs. walking). In that study, children with WS performed better than mental age-matched controls and at a level similar to normal adults. Jordan et al.'s findings suggest that children with WS have intact perception of both the qualitative nature of different kinds of motion and their direction, a conclusion that is consistent with the capacity of children, reported here, to accurately name different manners of motion. Clearly, however, further research is required to fully understand how motion perception operates in children with WS and how it delivers information to the linguistic system for appropriate encoding.

Of all the components of the motion event, the Path exhibited the most fragility: Children with WS both omitted Path altogether and produced vague intransitive Path expressions more often than normally developing children of the same mental age. Yet even this fragility occurred in the context of surprising control over the rich and subtle semantic structure required for the proper use of spatial terms. For example, the three Path types portraye (Bounded TO, FROM, and VIA) each elicited a different, constrained set of terms among children with WS that overlapped considerably with those of control children and even adults. Violations resulting from inappropriate use of a term from one Path type to another were rare, with the exception of the use of *over* to describe Bounded TO Paths, Bounded FROM Paths, and VIA Paths (in the latter, incorrectly expressing "through" Paths). We speculate that the abundant use of *over* stems in part from its high degree of polysemy in the language (Brugman, 1981; Lakoff, 1987) and possibly its relatively high frequency in the language. The result of polysemy could be that the child's representation of *over* is more loosely constrained than that of other terms and therefore it becomes the default term to be retrieved under conditions of uncertainty. Other major violations that crossed Path type were possible but did not occur; for example, *on* was never used instead of *off*, or *in* instead of *out*. Moreover, there were no violations of Ground object selection; for example, *on* and *off* were used in combination with "surface" Ground objects, and *in* and *out* were produced for "container" Ground objects.

The most pronounced and systematic difference between the children with WS and the normal children was not, however, the tendency to produce blatantly incorrect Path terms. Rather, the children with WS tended to either omit mention of the Path at all, to do so in a truncated or highly general fashion by using ambiguous intransitives (largely, *over*), or to omit mention of the Ground object. Each of these patterns suggests a certain fragility in the construction of the Path expression. Importantly, however, these patterns did not occur in blanket fashion across the events. Rather, they were constrained by the type of Path portrayed. Children with WS tended to omit expressions or use vague expressions of Path in contexts where the event portrayed a Figure object moving either away from a Ground object (Bounded FROM) or along a path passing the Ground object (VIA), but not in contexts where the Figure moved to a Ground object (Bounded TO). Their omissions were grammatical; they just failed to express the Path selectively in these contexts, whereas control children tended to include mention of the Path more often and did not show any effects of Path type on their omissions.

We believe that this pattern of selective fragility is best explained as a consequence of the interaction of the children's linguistic representations with their nonlinguistic spatial system, which is impaired. The nonlinguistic spatial deficit characteristic of WS appears most prominently in tasks requiring the retention of visual–spatial information over time (Wang & Bellugi, 1994), for example, the representation of spatial relationships, which then must be reconstructed in an adjacent but separate space. In the auditory domain, Vicari, Brizzolara, Carlesimo, Pezzini, and Volterra (1996) found that children with WS show the normal recency effect in memory for lists, with an advantage for items at the end of a list, but they do not show the normal primacy effect, as they show no advantage for items presented at the beginning of the list (Vicari et al., 1996). Our findings suggest a possibly parallel effect for visual–spatial memory, which could be responsible for selective difficulty encoding the Ground object in Bounded FROM and VIA Paths relative to encoding these in Bounded TO Paths. In the former two path types, the Figure's final resting place does not coincide with the Ground object, perhaps making it more difficult to retain an accurate representation of the Ground object. Similarly, relative difficulty in representing and retaining the Ground object would have an impact on the accurate representation of Path because the nature of the Path depends on the relationship between the Figure and Ground at the beginning of the event compared to their relationship at its conclusion.

We favor this account of Path and Ground object omissions because it closely ties the fragility that we observed in the children's spatial language to the mechanisms by which we can describe what is currently or recently perceived. Put simply, if the child cannot retain a representation of the Ground object or Path over time, he or she will not be able to talk about them. This explanation suggests that the observed fragility resides in spatial cognition, but is reflected in spatial language. Interestingly, this idea is compatible with the fact that languages, by and large, have more resources devoted to expressing TO paths than FROM paths. For example, there are more languages whose case system formally marks the former than the latter Path type. Further, there are a number of prepositions that mark both static locations "at" a Ground object and Paths TO a Ground object (e.g., in, under, between), whereas there are none that double in marking FROM paths and static locations "NOT at" a Ground object (R. Jackendoff, personal communication).

Other possibilities seem less likely to us. For example, the fragility could in principle be due to the status of Path terms as closed class terms. However, the names for Ground objects, which are open class terms, are also selectively omitted under the same circumstances as Path terms, suggesting that the problem cannot be completely explained by the closed class/open class distinction. This possibility could be directly tested, however, by examining the language of children with WS who are learning Path-incorporating languages such as Spanish or French. If the fragility is due to a nonlinguistic spatial deficit, and not to the difficulty of acquiring closed class items, the children should show fragility in the expression of Path (encoded by verbs) and Ground objects when talking about FROM and VIA Paths. Another possibility is that the fragility reflects a deficit in the actual meanings encoded by Path terms; that is, the idea that the meanings of the omitted elements are more difficult, or less richly represented, than those that are preserved. We regard this as unlikely because of the overwhelming evidence for rich spatial structure in the semantics of the Path expressions produced by the children with WS. With very few exceptions, the terms that were produced by the children reflected the appropriate semantic constraints characteristic of each of the components of the motion event, including all Path types. The fragility appeared in highly selective fashion—in just those contexts where it might be difficult to retain spatial information about the event. Thus it seems likely that it is linked to the nonlinguistic representation of the event: In FROM-path events, the Ground object and Path were not represented in a fashion robust enough to receive linguistic encoding.

Although our explanation links the selective deficit in spatial language to a selective nonlinguistic spatial impairment in WS, we cannot rule out the possibility that other kinds of mental retardation would lead to the same selective deficit. Moreover, because our normally developing children had above average IQs, it is possible that the fragility seen among children with WS was accentuated (see Mervis & Robinson, 1999, for discussion of issues pertaining to control groups). However, we view the highly selective deficit in spatial language among our children with WS as strongly compatible with our proposed explanation.

The general pattern of sparing and selective deficit can be used to gain an understanding of how spatial cognition interacts with the acquisition and use of spatial language in children. The strengths displayed by the children with WS in describing motion events reflect, we believe, knowledge of spatial language that has emerged in spite of the children's spatial deficit. Appropriate encoding of the central elements of a motion event in grammatical structures reflects the capacity to represent those aspects of objects, motions, and spatial relationships that are encoded by language. The performance by the children with WS suggests that, despite their profound spatial deficit, they have the capacity to acquire and use rich spatial representations embodied in the semantics of natural languages. Even the most fragile elements—Path terms—are acquired, and hence are part of the children's representations of spatial language.

How, then, can one explain the acquisition of such spatial language, in the face of profound deficit in other arenas of spatial representation? We speculate that spatial language, like many other systems of spatial cognition, has developed evolutionarily as a system which is specialized in the sense of having properties that are not directly and completely mapped from other spatial systems. Because of this specialization, the properties of space that must be represented in order to competently talk about space may be rather different from those properties of space that are required for competence in other spatial domains. The upshot is that it may be possible to acquire most aspects of spatial language even when other aspects of spatial representation are impaired.

This speculation rests on two pieces of evidence. The first is burgeoning evidence from cognitive neuroscience that spatial cognition is not one monolithic system, but rather, multiple systems specialized to represent different kinds of spatial information. One prominent example is provided by Milner and Goodale (1995), who argued that the system guiding action has quite different functional requirements from the system guiding perception; these different requirements are embodied in the computations performed by the two systems. The motor system, for example, must compute precise metric information continuously online as actions are applied to objects in the world. The perceptual system, in contrast, computes a different kind of information, building representations of the enduring qualities of objects. These two spatial systems appear to be represented by different areas of the brain, and perhaps as a consequence are differentially affected by different kinds of brain damage. Although research on brain structure in individuals with WS is in its infancy, evidence is compatible with the idea that there may be differential sparing of areas involved in spatial computations. In particular, there may be disproportionate reduction of volume in parietal and occipital lobes relative to the frontal lobe (Reiss et al., 2000).

The second piece of evidence supporting our speculation concerns the nature of spatial language, which appears to encode properties of objects and spatial relationships that are quite different from, and, in many cases, much coarser than, those required by the action or perception system. The Path types we have considered in this article serve as a good example. To navigate along a specific path, one would need to represent detailed metric information about its contours. However, such detail is not encoded by languages, which tend instead to encode only relatively coarse information, such as the distinction among Bounded TO, Bounded FROM, and VIA Paths. Within these Path types, English further distinguishes among paths on other bases, for example, the distinction between conclusion at an object's surface versus its interior (*on* vs. *in*). Such coarse coding of spatial information has been noted frequently as a characteristic of the incomplete mapping between spatial language and other spatial cognitive systems (e.g., Landau & Jackendoff, 1993; Talmy, 1983). Objects provide another example. Nonlinguistic representations of objects preserve shape and are sensitive to orientation relative to the viewer (Tarr & Bülthoff, 1995); they can also encode the orientation of the object relative to the head, the hand, and other body frames of reference for the purposes of reaching and grasping (Milner & Goodale, 1995). However, names for objects range over sets of similar objects and disregard specific orientation and location.

Thus spatial language would appear to possess properties distinct from other spatial cognitive systems. Given the requirements for rather different kinds of representations, the development of spatial language might not require that all aspects of nonlinguistic spatial cognition be fully intact. That is, it may be possible to acquire representations that encode distinctions pertinent to spatial language while failing to acquire representations pertinent to another spatial system. Recalling our discussion of motion perception, we suggested that it could be possible to normally acquire and use manner-of-motion verbs even if certain aspects of motion perception are impaired. Because language tends to encode spatial properties relatively coarsely, acquiring spatial language may not require that all aspects of spatial representation are intact. We speculate that this is the case in children with WS, who exhibit profound deficits in certain domains of spatial cognition, but show remarkably spared and rich knowledge of the language by which we represent spatial events.

ACKNOWLEDGMENTS

We thank James Hoffman, Helene Intraub, Ray Jackendoff, Michael McCloskey, and Colin Phillips for helpful comments on a draft of this article. We also thank Ted Supalla and Elissa Newport for making available the stimuli from their Verbs of Motion Production task, and Nicole Kurz and Litza Stark for help in transcribing and coding the data reported in this article. We thank the children who participated in these studies, their parents, and the organizations that helped us locate these participants. The latter organizations include the Williams Syndrome Association, the University of Delaware Preschool, and the Mom's Club chapters of Hockessin, Pike Creek, and Newark, Delaware. This research was supported in part by Grant No. 12-FY99-670 from the March of Dimes Birth Defects Foundation and Grant SBR-9808585 from the National Science Foundation.

REFERENCES

Atkinson, J., King, J., Braddick, O., Nokes, L., Anker, S., & Braddick, F. (1997). A specific deficit of dorsal stream function in Williams' syndrome. *NeuroReport, 8,* 1919–1922.

Bellugi, U., Bihrle, A., Neville, H., Doherty, S., & Jernigan, T. L. (1992). Language, cognition, and brain organization in a neurodevelopmental disorder. In M. Gunnar & C. Nelson (Eds.), *Developmental behavioral neuroscience: The Minnesota symposia on child psychology.* Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Bellugi, U., Wang, P. P., & Jernigan, T. L. (1994). Williams syndrome: An unusual neuropsychological profile. In S. H. Broman & J. Grafman (Eds.), *Atypical cognitive deficits in developmental disorders* (pp. 23–56). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Bihrle, A. M., Bellugi, U., Delis, D., & Marks, S. (1989). Seeing either the forest or the trees: Dissociation in visuospatial processing. *Brain and Cognition, 11,* 37–49.

Bowerman, M. (1996). Learning how to structure space for language: A crosslinguistic perspective. In P. Bloom, M. A. Peterson, L. Nadel, & M. F. Garrett (Eds.), *Language and space* (pp. 385–436). Cambridge, MA: MIT Press.

Brown, R. (1973). *A first language: The early stages*. Cambridge, MA: Harvard University Press.

Brugman, C. (1981). *Story of over*. Unpublished manuscript, Indiana University Linguistics Club.

Clahsen, H., & Almazan-Hamilton, M. (1999). Syntax and morphology in Williams syndrome. *Cognition, 68,* 167–198.

Clark, H. H. (1973). Space, time, semantics, and the child. In T. E. Moore (Ed.), *Cognitive development and the acquisition of language.* New York: Academic.

Elliot, C. D. (1990). *Differential Abilities Scale*. San Diego, CA: Harcourt Brace.

Fillmore, C. J. (1997). *Lectures on deixis.* Stanford, CA: CSLI.

Gruber, J. (1976). *Lexical strucures in syntax and semantics*. Amsterdam: North-Holland.

Herskovits, A. (1986). *Language and spatial cognition: An interdisciplinary study of the prepositions in English.* Cambridge, England: Cambridge University Press.

Hoffman, J., & Landau, B. (2000). *Preservation of object recognition despite profound spatial deficit: Evidence from children with Williams syndrome.* Poster presented at the Annual Meeting of the Cognitive Neuroscience Society, San Francisco.

Hoffman, J., Landau, B., & Pagani, J. (in press). Spatial breakdown in spatial construction: Evidence from eye fixations in children with Williams syndrome. *Cognitive Psychology*.

Jackendoff, R. (1983). *Semantics and cognition*. Cambridge, MA: MIT Press.

Johnson, S. C., & Carey, S. (1998). Knowledge enrichment and conceptual change in folkbiology: Evidence from Williams syndrome. *Cognitive Psychology, 37*(2), 156–200.

Jordan, H., Reiss, J. E., Hoffman, J. E., & Landau, B. (2002). Preserved perception of biological motion in the fact of severely impaired spatial cognition: Williams syndrome. *Psychological Science, 13*(2), 162–167.

Karmiloff-Smith, A., Grant, J., Berthoud, I., Davies, M., Howlin, P., & Udwin, O. (1997). Language and Williams syndrome: How intact is "intact"? *Child Development, 68*(2), 246–262.

Kaufman, A. S., & Kaufman, N. L. (1990). *Kaufman Brief Intelligence Test*. Circle Pines, MN: American Guidance Service.

Lakoff, G. (1987). *Women, fire, and dangerous things.* Chicago: University of Chicago Press.

Landau, B., & Jackendoff, R. (1993). "What" and "where" in spatial language and spatial cognition. *Behavioral and Brain Sciences, 16,* 217–265.

Langacker, R. W. (1987). *Foundations of cognitive grammar.* Stanford, CA: Stanford University Press.

Mervis, C. B., & Bertrand, J. (1997). Developmental relations between language and cognition: Evidence from Williams syndrome. In L. B. Adamson & M. A. Romski (Eds.), *Communication and language acquisition: Discoveries from atypical language development* (pp. 75–106). Baltimore: Brookes.

Mervis, C. B., & Robinson, B. F. (1999). Methodological issues in cross-syndrome comparisons: Matching procedures, sensitivity (SE) and specificity (SP). In M. Sigman & E. Ruskin (Eds.), *Continuity and change in the social competence of children with autism, Down syndrome, and developmental delays* (pp. 115–130). London: Blackwell.

Mervis, C. B., Morris, C. A., Bertrand, J., & Robinson, B. F. (1999). Williams syndrome: Findings from an integrated program of research. In H. Tager-Flusberg (Ed.), *Neurodevelopmental disorders: Contributions to a new framework from the cognitive neurosciences* (pp. 65–110). Cambridge, MA: MIT Press.

Milner, A., & Goodale, M. (1995). *The visual brain in action.* New York: Oxford University Press.

Newport, E. L. (1990). Maturational constraints on language learning. *Cognitive Science, 14,* 11–28.

Pustejovsky, J. (1991). The syntax of event structure. *Cognition, 41,* 47–81.

Reiss, A. L., Eliez, S., Schmitt, J. E., Straus, E., Lai, Z., Jones, W., et al. (2000). Neuroanatomy of Williams syndrome: A high-resolution MRI study. *Journal of Cognitive Neuroscience, 12*(1), 65–73.

Singleton, J., & Newport, E. L. (in press). When learners surpass their models: The acquisition of American Sign Language from inconsistent input. *Cognitive Psychology*.

Stevens, T., & Karmiloff-Smith, A. (1997). Word learning in a special population: Do individuals with Williams syndrome obey lexical constraints? *Journal of Child Language, 24,* 737–765.

Supalla, T. (1982). *Structure and acquisition of verbs of motion and location in American Sign Language*. Unpublished PhD thesis, University of California, San Diego.

Talmy, L. (1975). Semantics and syntax of motion. In J. Kimball (Ed.), *Syntax and semantics* (Vol. 4, pp. 181–238). New York: Academic.

Talmy, L. (1983). How language structures space. In H. Pick & L. Acredolo (Eds.), *Spatial orientation: Theory, research, and application* (pp. 225–282). New York: Plenum.

Tarr, M. J., & Bülthoff, H. H. (1995). Is human object recognition better described by geon- structural-descriptions or by multiple-views? *Journal of Experimental Psychology: Human Perception and Performance, 21,* 1494–1505.

Vicari, S., Brizzolara, D., Carlesimo, G. A., Pezzini, G., & Volterra, V. (1996). Memory abilities in children with Williams syndrome. *Cortex, 32,* 503–514.

Wang, P. P., & Belllugi, U. (1994). Evidence from two genetic syndromes for a dissociation between verbal and visual–spatial short-term memory. *Journal of Clinical and Experimental Neuropsychology, 16*(2), 317–322.

Wang, P. P., Doherty, S., Rourke, S. B., & Bellugi, U. (1995). Unique profile of visuoperceptual skills in a genetic syndrome. *Brain and Cognition, 29,* 54–65.

APPENDIX
Descriptions of the 80 Events, Taken From Newport (1990)

Figure-Only Events

1. A loop moves diagonally upward
2. A ruler moves across a lawn
5. A baby wanders across the floor
7. A porcupine walks, turns, and walks again
11. An ashtray zigzags across a lawn
12. An airplane moves, turns, and moves
13. An airplane hops in a straight line
15. A barrel hops downhill
19. A man rolls across a lawn

21. A green locomotive moves, turns, and moves
22. A yellow towel zigzags across a lawn
23. An upright wooden bar falls over
27. A broom sweeps slowly and randomly across the floor
28. A toilet moves across the floor
29. A tree hops in a straight line
30. A hen hops uphill
33. A tree moves in a straight line
35. A paper glider flies up and down through the air
39. An upright phonebook falls down
40. A green creature flies through the air in a spiral fashion
42. A cylinder rolls across a lawn
43. A balsa wood glider moves, turns, and moves again
45. A knife moves, turns, and moves
47. A Band-Aid moves, turns, and moves
48. A palm tree flies through the air in a spiral fashion
52. An airplane flies through the air in a spiral fashion
53. A fire hydrant moves, turns, and moves again
54. A thin oil paint brush flies backward in a spiral fashion
56. A fat yellow bee wanders across the floor
57. An upright roll of duct tape falls over
59. A movie reel rolls diagonally upward
61. A rabbit hops slowly downhill
62. A motorcycle moves, turns, and moves
63. A cactus falls over
67. A barrel-half tips over
69. A piece of bone falls over
70. An egg flies up and down through the air
72. A rescue truck zigzags uphill
76. A motorcycle hops slowly downhill
78. A wooden bar spins slowly downhill

Figure-Ground Events

3. A girl jumps into a plumbing nut
4. A cylinder falls off of a swing
6. A white pipe cleaner jumps from a cactus
8. An airplane flies through a plastic T-pipe
9. A Christmas tree jumps up onto a box
10. A wreath falls down from above a fireplace
14. A tractor moves backward and turns toward a book

16. A loop jumps over a tree
17. A chick flies diagonally up to a wooden rod
18. A tricycle moves toward a mail truck and turns to avoid it
20. A dart with a suction cup flies and hits the wall of a building
24. A tail wing falls off of a Lego airplane
25. A duck walks past a thin loop
26. A bed moves around a prone man
31. A cup jumps onto the head of a frog
32. A missile jumps backward on top of another missile
34. A metal washer jumps out of an ashtray
36. A lawnmower moves toward a palm tree and turns to avoid it
37. A roll of paper jumps through a roll of tape
38. A dog jumps backward over a bed
41. A brick jumps down off of another brick
44. A Q-tip flies through a metal washer
46. A VW bug falls off of a thick loop
49. A pickup truck hits a tree
50. A woman walks backward past a dog
51. An airplane takes off from the back of a tugboat
55. A hollow log jumps over a stump
58. A farmer falls from the branch of a tree
60. A soup can falls off of an upright dart
64. A green jeep pulls out of a hollow log
65. A doll jumps down from the head of another doll
66. A doll walks by an airplane and turns to it
68. A floor lamp moves toward a table and turns to avoid it
71. A thick paint brush moves backward into an empty tin can
73. An evergreen falls down off of a red pole
74. A tugboat moves backward from a yellow pole
75. A turtle walks backward and turns toward a tree
77. A robot walks and turns toward a motorcycle
79. A rabbit falls backward from the back of a zebra
80. A pencil moves backward from a yardstick