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The development of PATHS: Spatial complexity and the multiple predicate strategy

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Abstract

Elicited production data from English, French and Japanese children reveal that predicates of 'traversal' (e.g. *across*, *through*) present a particular lexicalization difficulty in the early stages of acquisition, regardless of expression in verbs or adpositions. Adult-like lexicalization patterns are consistently produced only by 6 or 7 years old. In all three languages, children circumvent the problem in the same way: by linguistically splitting such trajectories into subevents. This unexpected finding remains in need of more targeted investigation, but two possible accounts are considered. That these predicates are set apart due to elaborate lexical semantic structures is shown to be in contradiction with recent generative analyses. A more plausible account is offered in terms of relative complexity in the integration of non-linguistic spatial representations.

1 Introduction

This paper presents evidence that the concepts expressed by predicates of 'traversal' (e.g. *across*, *through*) present a particular lexicalization difficulty for children, who initially circumvent the problem by linguistically splitting such concepts into subevents. Elicited production data from English, French and Japanese children reveal that the same strategy is adopted irrespective of the language being acquired, and irrespective of linguistic expression in either verbs (V) or pre/postpositional phrases (PP). Each language reveals a marked contrast between predicates of traversal and other directional predicates expressing paths to a goal (e.g. *to*, *into*), from a source (e.g. *from*, *off*), or medial trajectories (e.g. *up*, *down*). As the exposition is data-driven, the first half of this study is descriptive: examples of highly recurrent speech patterns reveal children's early reliance on the multiple predicate strategy, instances of which gradually decline until its disappearance at about 6 or 7 years old. I begin in the following section with a general outline of the experiment: its purpose, subjects, settings, and methodology. The relevant findings are then presented in Section 3. The latter half of the study turns to theoretical implications of this developmental discrepancy. In Section 4, one theoretical extrapolation is considered, in which a link is posited between lexical semantic complexity and order of lexical acquisition, such that predicates of traversal require more elaborate lexical semantic representation than those expressing 'simpler' trajectories. However, in

Section 5, I maintain that it is more plausible to posit that differences in the complexity of trajectories are delineated in an independent mental module of spatial representations. On this view, all directional predicates of the same syntactic category have the same level of semantic complexity, and the delay in acquisition is plausibly due to non-linguistic factors. The experimental evidence presented here is based on unexpected results from an investigation targeting other issues. What follows is therefore a presentation of an intriguing set of findings which constitute groundwork for further research.

2 Experimental methodology

2.1 Original experimental goals

The data discussed here are drawn from an elicited production experiment investigating the much more general issue of how languages encode basic trajectories in motion events.[1] In Talmy's (1991; 2000b) binary typology, 'satellite-framed' languages such as English, Russian and Chinese systematically encode the conceptual feature PATH (or 'direction') in adpositions, e.g. {*swim <u>across</u> the river* / *run <u>in(to)</u> the house*}, whilst 'verb-framed' languages such as Japanese, French, and Arabic generally do so in verbs, e.g. {'*<u>cross</u> the river swimming*' / '*<u>enter</u> the house running*'}. In order to bring acquisitional evidence to bear on this phenomenon, an experiment was conducted with 95 monolingual English-, French-, and Japanese-speaking children from 3 to 7 years, with adult control groups. Utterances with directional predicates were elicited using a purpose-designed picture-story, illustrating events with both MANNER and PATH. Each experiment was recorded on micro-cassette, all responses related to the materials were transcribed, and 1608 examples of PATH predication were selected for analysis.

2.2 Elicitation materials and procedure

The picture-story was in horizontal layout, brightly coloured, and laminated to allow for handling by many young children. It was bound at the top to avoid any confusion about whether the pages should turn left-to-right as in all English and French children's books, or right-to-left as in most (but not all) Japanese children's books. The action on each page proceeds from left to right as the main character begins his adventure, from right to left as he returns home. Pages targeting motion events were divided into two or three cartoon frames, as is standard in many published children's picture-books. However, the return journey was represented all on one page, with multiple images of the monkey. This change of format served three functions: first, in the case of unsuccessful elicitation first time around, it provided a second

opportunity for a response; second, two responses to the same motion event, separated by a time interval with talk of other events, created a greater chance of lexical and syntactic variation in the same speaker's responses, adding to the breadth of the investigation; and third, the second set of stimuli were intended to counterbalance any possible unwanted 'frame effects', such as the participants focussing on the action in each cartoon frame rather than on the page's representation of the action as a whole event.

The narrative runs as follows: a monkey sits in a tree-house about to eat his banana; a parrot swoops in, steals the banana, and flies off. The monkey chases the parrot, determined to retrieve his banana. Their chase takes the monkey through several different spatial environments. On each page relevant to the analysis, he follows a particular trajectory (e.g. 'down', 'under', 'over', etc.), varying with the obstacles he encounters, and he exhibits a particular manner of motion (e.g. he 'slides' down a tree-trunk, 'runs' under a bridge, 'jumps' over a rock etc.). The monkey follows the parrot into a cave, where they encounter a lion. The lion chases them out of the cave, after which the parrot drops the banana and flies away. The monkey recovers it, then retraces his steps back home as fast as he can, going through all the motions a second time, before eating his banana in peace.

The experiment made use of a simple and relatively straightforward elicitation procedure. The experimenter introduced each page by describing the location, in order to encourage subjects to focus on trajectory rather than locational setting.[2] Subjects were then asked to describe the monkey's actions. For example, the scene in which the monkey jumps over a rock was introduced in English as follows:

> 'and now look, he's running along, and there's a rock in the middle of the path. So what does the little monkey do?'

If subjects did not describe the path followed by the monkey, but rather described the MANNER ('he jumps') or commented on the monkey's emotions ('he's very cross'), a prompting strategy was adopted to elicit appropriate responses; the use of directional predicates of any type was scrupulously avoided in the prompts. This technique was a major departure from previous 'narrative-oriented' research on motion events (e.g. the papers in Berman and Slobin, 1994; Strömqvist and Verhoeven, 2004). Such a strategy would be disastrous for the investigation of rhetorical styles, because of frequent interruptions in the storytelling, and the discounting of first responses in such instances. However, this form of elicitation made possible the systematic targeting of particular lexical and syntactic types, so that each pictorial stimulus produced at least one example of PATH predication from each test subject.

2.3 Test subjects and settings

A total of 95 English, French and Japanese monolingual[3] test subjects successfully participated in this experiment. In each language, the children were divided into 5 age groups from 3 to 7 years, and there was a sixth group with adult test subjects. There were on average 5 participants in each age group (2 groups of 4, 12 groups of 5, 1 group of 6, and 3 groups of 7). The elicitation task was carried out in a quiet room at school, in the presence of one experimenter and one research assistant known to the child (school teachers in England and France; a school teacher and a school teaching assistant in Japan). Adults were tested under the same experimental conditions, but with just the experimenter present.

3 Results for THROUGH and ACROSS: The splitting of complex trajectories

Children's expressions of the concepts of THROUGH and ACROSS in all three languages furnished a strong and unexpected developmental pattern that merits discussion. The responses reveal that 3- and 4-year olds consistently split the complex trajectories of these predicates, expressing either one sub-event or a combination of sub-events, whilst the older children and adults consistently lexicalized the whole trajectory in V or PP (English: *through, across*; *cross*; French: *traverser* 'cross'; *(aller) de l'autre côté* '(go) to the other side'; Japanese *wataru* 'cross', *yokogiru* 'cross', *kuguru* 'go under (and out the other side)', *mukōgishi mad*e 'to the other side', or alternatively, in a V^P combination such as French *passer dans* 'go.via in' (= 'go through'). This was in stark contrast to the lack of such a developmental pattern for trajectories such as UP, DOWN, IN and OUT which were invariably expressed in a single V, P, or V^P combination, by all participants in all age groups.[4] As can be seen from a cursory glance at the above examples, this is tangential to any description of a particular language as having 'verb-framed' or 'satellite framed' preferences, as expression in either V or PP is possible in each language.[5]

What younger test subjects did is best illustrated by example. The following are sample responses in English, French and Japanese, to the scenes in which the monkey crawls through a hollow tree trunk (THROUGH), and swims across a river (ACROSS), by the two extremes: 3-year-olds and adults (ages in years and months are indicated on the left).[6]

English: Examples of split and whole trajectories

THROUGH condition:

(1)	a.	*he goes in it…he comes out* (split into 2 sub-events)	(3;3)
	b.	*goes under the trunk* (only 1 sub-event)	(3;9)
	c.	*he crawls through it* (whole trajectory lexicalized in P)	(Adult)

ACROSS condition:

(2)	a.	*he gets in the water…swims…gets out* (split into 3 sub-events)	(3;11)
	b.	*he splashes into it and then gets out* (split into 2 sub-events)	(3;4)
	c.	*he swims across the river* (whole trajectory lexicalized in P)	(Adult)

French: Examples of split and whole trajectories

THROUGH condition:

(3)	a.	*il va dans le tronc d'arbre et il sort* he goes in the trunk of.tree and he comes.out 'He goes into the tree trunk and he comes out.' (split into 2 sub-events)	(3;1)
	b.	*il rentre dedans* he enters inside 'He goes inside.' (only 1 sub-event)	(3;2)
	c.	*il passe dans le tronc d'arbre* he goes.via in the trunk of.tree 'He goes through the tree trunk.' (whole trajectory expressed in V^P)	(Adult)

ACROSS condition:

(4)	a.	*il va dans la rivière, il nage, il ressort* he goes in the river, he swims, he again.gets.out *de la rivière* of the river 'He goes into the river, he swims, he gets out of the river again.'	(3;6)

(split into 3 sub-events)

b. *il va dans la rivière* (3;2)
he goes in the river
'He goes into the river.'
(only 1 sub-event)

c. *il traverse la rivière en nageant* (Adult)
he crosses the river by swimming
'He swims across the river.'
(whole trajectory lexicalized in V)

Japanese: Examples of split and whole trajectories

THROUGH condition:

(5) a. *koko ni hairu sore de de-te-kuru* (3;10)
here LocP enter that by exit-TE-come
'He goes in here, so he comes out.'
(split into 2 sub-events)

b. *ki o mogu-tte koo ya-tte…*[7] (3;10)
tree ACC go.under-TE like.this do-TE
'He goes under the tree, he goes like this.'
(only 1 sub-event)

c. *tsutsu no naka o kugu-tte-imasu*[8] (Adult)
tube GEN inside ACC go.via.under-TE-PROG
'He's going through the tube.'
(whole trajectory lexicalized in V)

ACROSS condition:

(6) a. *jabun-tte hai-tte ne sorekara deta* (3;7)
splash-TE enter-TE PART after.that got.out
'He went in with a splash, and after that he got out.'
(split into 2 sub-events)

b. *kawa ni zapon-te haicha-tta* (3;6)
river LocP splash-TE enter.ASP-PST
'He splashed into the river.'
(only 1 sub-event)

c. *kawa o oyoi-de wata-tte-imasu* (Adult)
river ACC swim-TE cross-TE-PROG
'He's swimming across the river.'
(whole trajectory lexicalized in V)

In each language there was a development from the younger children's multiple predicate strategy to the adults' consistent expression of the whole trajectory in a single predicate (or V^P combination). The results for predicates of traversal were crystal clear in English, and whilst there were exceptions in particular French and Japanese age groups, the developmental trend remains unmistakable in each language. A detailed breakdown of the results is given in Figures 1-6 in the appendix; here I provide a brief summary of response patterns for the THROUGH and ACROSS conditions in each language.

The English responses, shown in Table 1 (Figures 1 and 2 in the appendix), reveal a gradual progression from the multiple predicate strategy to the expression of the trajectories in a single lexical item: *through* (P); *across* (P); or *cross* (V).

The French results, shown in Table 2 (Figures 3 and 4 in the appendix), reveal an extremely similar development, with the exception of Group F7 responses to the THROUGH condition, in which the whole trajectory was lexicalized in only 20% of cases. There is no ready answer for why this was the case. The other French age groups developed the same pattern in both conditions, towards expression in a single LI or a V^PP combination: *à travers* 'through' (P); *traverser* 'cross' (V); *passer {dans / à l'intérieur de}* 'go-via {in / LocP the inside of}' (V^PP).

The Japanese results, given in Table 3 (Figures 5 and 6 in the appendix), show a similar progression but with two age groups bucking the trend, each in one condition only. Whilst the overall pattern for the THROUGH condition is the same as in English and French, Group J3 had a

Table 1. *Expression of whole trajectory in a single instance of predication: the THROUGH and ACROSS conditions in English.*

	3years	4years	5years	6 years	7 years	Adult
THROUGH	0.0%	50.0%	80.0%	80.0%	70.0%	100.0%
ACROSS	7.1%	20.0%	90.0%	90.0%	100.0%	100.0%

Table 2. *Expression of whole trajectory in a single instance of predication: the THROUGH and ACROSS conditions in French.*

	3years	4years	5years	6 years	7 years	Adult
THROUGH	20.0%	20.0%	62.5%	60.0%	20.0%	85.7%
ACROSS	0.0%	0.0%	26.6%	44.4%	60.0%	100.0%

Table 3. *Expression of whole trajectory in a single instance of predication: the THROUGH and ACROSS conditions in Japanese.*

	3years	4years	5years	6 years	7 years	Adult
THROUGH	60.0%	50.0%	100.0%	85.7%	100.0%	100.0%
ACROSS	11.1%	22.2%	66.7%	27.3%	100.0%	100.0%

relatively high rate of whole-trajectory expression, at 60%. The other exception, in the ACROSS condition, is the clear dip as Group J6 lexicalized the whole trajectory in only 27.3% of cases. Again, I have no account for these exceptions, and my prediction would be that such effects might be eliminated with a larger pool of test subjects. As in English and French, the overall development in Japanese was toward expression of the whole trajectory in a single syntactic clause, either in a simple or compound V, or in a PP: *kuguru* 'go-via-under' (V); *wataru* 'cross' (V); *tōrinukeru* 'go-via-emerge' (V-V compound); *kugurinukeru* 'go-via-under-emerge' (V-V compound); *mukōgishi mad*e 'to the other side'(PP).

A natural concern arises in respect of the methodology. Test materials with multiple cartoon frames might in other circumstances be held responsible for the linguistic fragmentation into subevents. However, two considerations render this an unlikely source of explanation.

Firstly, *all* the motion events were represented in two or three cartoon frames on the monkey's outward journey, yet the elicited production data revealed consistent decomposition into sub-events only with THROUGH and ACROSS, and never with UP, DOWN, IN or OUT.[9] Whilst utterances such as *climb up the tree-trunk* (English 3 year-old) were typical of all age groups, responses such as 'The monkey goes onto the tree, then climbs up, then gets to the top' were not attested in any age group. A typical response by young French participants to the tree-trunk scene was *il monte* - he goes.up - 'he goes up' (French 3-year-old), and a typical Japanese response was *nobotteru* - climb-TE-PROG - 'he's climbing up' (Japanese 3 year-old).

Secondly, as indicated earlier, there were two pictorial stimuli for each trajectory: the outward journey was in cartoon-frame format, but the return journey was all on one page, precisely to control for unwanted framed effects. However, there was no discernable effect on responses by the difference in stimulus: whether the motion event was presented in the form of split images or whether it was shown in a single image, younger subjects split the trajectory, whilst older children and adults were holistic.

4 Lexical semantic complexity and delays in acquisition

4.1 The semantic feature hypothesis revisited

The first theoretical interpretation of these findings to be considered is that predicates of traversal require more complex semantic representations than those expressing 'simpler' trajectories, and that this additional complexity is directly linked to the relative delay in acquisition. This idea has its roots in research on lexical acquisition conducted in the 1970s, and has undergone a second flowering in more recent lexical semantic work. However, whilst it

remains a viable proposition in certain areas of acquisition, I argue that it is ultimately inapplicable in this particular case.

In an influential, early study of the acquisition of concepts, Clark (1973) set out the 'semantic feature hypothesis', proposing that if complex concepts are learned later than the primitives by which they are defined, *words* expressing complex concepts will be learned later than the *words* expressing primitive components. Implicit in this original version of the hypothesis what is sometimes referred to as the 'classical view' of concepts, stemming from ideas on the nature of categorization developed by empiricist philosophers such as Locke (1690/1964) and Hume (1739/1978). The classical view holds that word meaning may be defined in terms of constituent concepts. Primitive concepts may combine to form complex concepts. Concept acquisition may thus be analysed as the process of building complex concepts from the primitive base. In an insightful discussion of these ideas, Carey (1982) suggests that concepts may be viewed as primitive in at least three different senses: (i) if there is a single set of concepts out of which all other concepts expressible in the language can be defined, then members of this set are *definitional primitives*; (ii) if there is a set of innate concepts, or at least very early-acquired concepts, out of which all other concepts are built, then members of this set are *developmental primitives* (iii) if there is a set of concepts constituted by the elements manipulated in thinking, then members of this set are *computational primitives* (Carey, 1982: 350-51). In these terms, meaning components in Clark's (1973) original 'semantic feature hypothesis' are primitives both definitionally and developmentally. Another important notion in the semantic features approach is that immature lexical entries should differ from the corresponding adult entries in predictable ways. The lack of one semantic component in a given lexical entry, or the inclusion of one or more incorrect components in the definition, should give rise to observable effects both in terms of comprehension and production.

The many acquisition studies in the 1970s and early 1980s inspired by this approach were at best inconclusive as to the psychological reality of lexical decomposition. For example, Carey (1982) provides a mostly negative review of studies investigating comparative spatial adjectives, i.e. elements such as *big, little*; *tall*, *short*; *deep*, and *shallow*. According to the assumptions of the time, the continuum sense of tall (as in 'How *tall* is the plant?' or 'It's 30cm *tall*') has fewer features than the contrastive sense (as in 'This plant is tall', i.e. taller than average, or 'This plant is taller than that one'). The former was assumed to have the features [adj], [comparative] and [height], whilst the latter was assumed to have an additional feature [+pole] (i.e. greater than the measurement of reference). The contrastive adjective *short* supposedly had only a contrastive sense, with a negative polarity feature, thus sporting the feature set [adj], [comparative], [height], and [-pole]. Several researchers used this analysis as a basis for the prediction that positive, unmarked adjectives (e.g. *tall*) should be acquired before negative,

marked adjectives (e.g. *short*), which does appear to be the case. When children are presented with arrays of objects and asked 'Which one is the {e.g. tall / short} one?', negative spatial adjectives induce significantly more errors (e.g. Bartlett, 1976; Brewer and Stone, 1975).

However, as Carey (1982) points out, this logic is rather shaky for several reasons. First, in all the relevant experimental work, adjectives such as *tall* were used in a contrastive sense, and therefore in this usage shared the same number of hypothesized features as adjectives like *short*. Secondly, a complementary prediction that the continuum sense should be learned earlier as it lacks the feature [+pole], which follows from this analysis, was never tested but is patently false.[10] Thirdly, Clark, Carpenter, and Just (1973) showed that adult reaction times to verify 'A is taller than B' are significantly faster than those to verify 'B is shorter than A', a difference which correlates with child errors across a range of adjectives. It seems likely that children make more errors with negative adjectives in experiments with arrays of objects because of a predisposition, shared with adults, to encode geometric differences between objects in positive terms. When children are asked to simply provide opposites (Clark, 1972) or answer yes-no questions about object properties (Carey, 1978a), they do so equally well for positive and negative adjectives.[11] Fourthly, *in any case*, if many negative adjectives are, in fact, acquired after their positive counterparts, this is likely to be due to factors other than feature-count, such as frequency in the input (Carey, 1982: 362). The weakness of this and other similar purported evidence for the role of semantic complexity in lexical acquisition leads Carey (1982) to conclude that, in general, the component-by-component approach to semantic acquisition is unfounded.

The decompositional approach to lexical semantics was also attacked during the 1970's and early 1980's in experiments measuring adult reaction times when presented with semantically simple and complex vocabulary items. For example, Fodor, Fodor and Garrett (1975) found that negatives that are lexically spelled out (e.g. *not married* rather than *unmarried*) increased processing time in an inference task, whilst the same putatively conflated semantic feature did not (*bachelor* rather than *unmarried man*). By the early 1980s, proponents of classical decomposition theories did not need to ask for whom the bell was tolling.

However, an exception to the rule in these early investigations was the study of Baron and Kaiser (1975), which found evidence for incomplete lexical entries for nominative pronouns. In theory, these elements are feature-marked for phi-features (person, number, gender), and animacy, but gender features in particular appeared to remain unspecified for a significant period of development, with within-child consistency over three different tasks. This prompts Carey (1982: 369) to reflect that 'component-by-component acquisition may hold only for components motivated syntactically as well as semantically'. More recent research has provided an intriguing continuation of this last strand of the debate.

4.2 The semantic features hypothesis revived

From the late 1980s through the 1990s to the present, considerable evidence has accumulated to support the notions that (i) decomposition in terms of grammatically-relevant semantic components is psychologically real; (ii) the set of grammatically-relevant components is larger than the set of phi-features; and (iii) such components do play a pivotal role in lexical acquisition.

Drawing on extensive resource materials from the MIT Lexicon Project in the 1980s, Levin (1993) shows how variation in syntactic argument structure can be used to discover which meaning elements in predicates might have syntactic effects. For example, the verbs (a) *cut*, (b) *crack*, (c) *stroke*, and (d) *whack* may seem conceptually similar at first glance, but detailed analysis reveals that they exhibit distinct syntactic behaviour. As shown below, the verbs *crack* and *stroke* may not be used in the 'conative' construction (1); *crack* may not be used in the 'body-part ascension' construction (2); and *stroke* and *whack* may not be used in the 'middle' construction (3):

(7) a. Harry cut at the pastry.
b. *Sally cracked at the parchment.
c. *Harry stroked at the cat.
d. Sally whacked at the door.

(8) a. Sally cut Harry on the hand.
b. *Sally cracked Harry on the tooth.
c. Sally stroked Harry on the leg.
d. Sally whacked Harry on the shin.

(9) a. This surface cuts easily.
b. Plastic cups crack easily.
c. *Puppies stroke easily.
d. *Footballs whack easily.

(adapted from Levin, 1993: 6-7)

When considered in semantic terms, it might be said that *cut* is a verb of causing a change of state by moving something into contact with the entity that changes state; *crack* is a pure verb of change of state; *stroke* is a pure verb of contact; and *whack* is a verb of contact by motion. These semantic aspects may be represented as features on the predicates, as follows:

(10) a. *cut*: [+ CAUSE, + CHANGE, + CONTACT, + MOTION]
b. *crack*: [+ CAUSE, + CHANGE]
c. *stroke*: [+ CONTACT]
d. *whack*: [+ CONTACT, + MOTION]

If this analysis is correct, then predictions can be made as to the syntax of verbs that share the same semantic features. Such predictions are borne out with the syntactic distribution of (a) *cut*–type verbs (*scratch*, *hack, slash* etc.); (b) *crack*–type verbs (*rip*, *break*, *snap* etc.); (c) *stroke*–type verbs (*tickle*, *pat*, *touch* etc.); and (d) *whack*-type verbs (*kick*, *hit*, *tap* etc.), leading to the conclusion that lexical semantic features do play a determining role in the syntax of argument structure.

The idea that features such as CHANGE (of state) and MANNER (of motion) play a role in acquisition has found strong support in studies such as Gropen, Pinker, Hollander and Goldberg (1991), who provided convincing experimental evidence that young children have early (perhaps innate) possession of the knowledge of semantics-to-syntax mapping in respect of locative verbs, with any errors presumably due to incomplete or inaccurate lexical entries. When presented with nonce verbs as new vocabulary items (i.e. in the absence of syntactic context), and asked to describe an purpose-designed event, children are remarkably accurate in their selection both of (i) the GROUND ('location') as the direct object of nonce verbs indicating a change of state (following the pattern of *She covered {the bed with a blanket / *a blanket onto the bed}*); and (ii) the FIGURE ('theme', or 'moving object') as the direct object of nonce verbs indicating a manner of motion (following the pattern of *She threw {the blanket onto the bed / *the bed with the blanket}*). Gropen et al (1991) showed that this was so from at least age 3;4, and their results were replicated by Stringer (2000) with younger test subjects, indicating that the mapping is fully understood from at least age 2;10 (eliciting full sentences from children younger than this, with subject, direct and indirect objects, is a tall order).

Such findings suggest that the semantic feature hypothesis is worthy of reconsideration, if restricted to those elements of meaning that play a demonstrable role in syntax. This appears to be the position taken by Pinker (1989: Ch.7), who explicitly attributes certain argument structure errors to lacking or superfluous elements in lexical semantic structures, for a range of syntactic phenomena. The immediate question is whether predicates of traversal may be characterized as having more complex lexical semantics than other directional predicates.

At first blush, it appears plausible that predicates such as English *through* or *across* (and their approximations in French and Japanese) might be analysed as having relatively complex lexical semantic representations. For example, in one of the earliest (and still one of the most thorough) attempts to characterize the semantics of English prepositions, Gruber (1976: 12-14) argues that *through* may be decomposed as follows:

(11) *through*: (ALL THE WAY) FROM ONE END TO THE OTHER IN

He notes that the object of the preposition *through* must have an inside, and that in a semantic derivation, the GROUND object starts as the object of a deep preposition IN. Whilst I do not assume such a derivational analysis, it seems true that there is an entailment relation between the English prepositions *through* and *in*. The alternatives in example (12a) below entail that the corresponding alternatives in (12b) are also true.

(12) a. Tim went through {Paris / the tunnel / the doorway}.
b. At some point, Tim was in {Paris / the tunnel / the doorway}.

Note that the last example of a GROUND object has no inside, as such: *through* can also be used to express a path from one side of a 2-dimensional plane to the other. Thus *in* expresses a more general sense of containment, construable by a frame as well as an enclosure.

Gruber proposes that *across* has a similar representation, with ON replacing IN, as *across* describes 'a transition of position on a surface' (Gruber (1976: 27). However, as can be seen in the examples below, this proposed entailment prediction is only sometimes, not always, borne out.

(13) a. Julie went across {the road / the bridge / the grass}.
b. At some point, Julie was on {the road /the bridge / the grass}.

(14) a. Julie {ran across the hall / flew across Paris in an aeroplane / cruised across the Atlantic in a submarine}.
b. At some point, Julie was {*on the hall / *on Paris / *on the Atlantic}.

Gruber's (1976) analysis of these prepositions contrasts with his use of IN, ON, UP, DOWN, which are treated as computational primitives (in the sense of Carey, 1982: 350-351) in lexical representations.[12]

However, in another treatment in the same tradition of analysis, Talmy (2000a: 248-252) elaborates representations that do not set predicates of traversal apart in their grain of lexical semantic complexity. The following examples correspond to the relevant senses of the predicates in my elicited production experiment: respectively, bounded paths *through a hollow tree trunk*, *across a river*, *in(to) a cave* and *up a tree*:[13]

(15) *through*: ALENGTH an $_{B}\text{EXTENT}_{S}$ that IS_{LOC} INSIDE, PARALLEL-TO, and COTERMINOUS-WITH [a BOUNDED CYLINDER] IN an $_{B}\text{EXTENT}_{T}$

(16) *across*: ALENGTH an $_{B}\text{EXTENT}_{S}$ that IS_{LOC} ON and COTERMINOUS-WITH [a BOUNDED PLANE] IN an $_{B}\text{EXTENT}_{T}$

(17) *in(to)*: TO a POINT_S that IS OF the INSIDE OF [AN ENCLOSURE]

(18) *up*: UP ALENGTH an $_B\text{EXTENT}_S$ that IS_{LOC} VERTICAL and IS_{LOC} ON, PARALLEL-TO, and COTERMINOUS-WITH [a VERTICAL BOUNDED LINE] IN an $_B\text{EXTENT}_T$

Whilst the representations of Gruber (1976) might lead one to expect the kind of developmental differences attested in the experiment, those of Talmy (2000a) do not make such a strong distinction between types of directional predicate (although note that TO and IN(SIDE) appear as primitives inside the complex representation of *into*, and UP appears inside the representation of *up*, whilst THROUGH is never a primitive). The predictions of such accounts in the tradition of cognitive semantics are less than clear in respect of the question of relative complexity. In contrast, as we shall see, there is a strong convergence in research in the generative paradigm, from both the perspectives of lexical semantics and syntax, which indicates that linguistic complexity is not a relevant factor in distinguishing between the two types of directional predicates.

5 Toward a non-linguistic solution: Complexity in the spatial representations of trajectories

5.1 Uniform linguistic complexity

More constrained lexicalist accounts in the tradition of generative grammar, which restrict the set of semantic components to those with observable syntactic effects, often posit that the various directional predicates discussed above have, in fact, exactly the same degree of linguistic complexity. For example, Jackendoff (1990: 45-47) suggests that English *into* corresponds to the structure in (19), and extrapolating from his analysis of the verb *climb* (op.cit. 76-79), I assume that the appropriate representation of the relevant sense of *up* in this framework is as in (20).

(19) $[_{\text{Path}}$ TO $([_{\text{Place}}$ IN $([_{\text{Thing}}$ __ $])])]$

(20) $[_{\text{Path}}$ TO $([_{\text{Place}}$ TOP-OF $([_{\text{Thing}}$ __ $])])]$

As for predicates of traversal, the intended sense of *through* is represented as follows (op.cit. 47, 72-74).

(21) $[_{\text{Path}}$ VIA $([_{\text{Place}}$ IN $([_{\text{Thing}}$ __ $])])]$

This representation also provides the required entailment relations discussed in the previous section. Although a detailed analysis of *across* is not given

in Jackendoff (1990), the various senses and their entailment relations can be easily captured by altering the Place-functions in the argument structure, and allowing different mappings to the phonological representation for the different senses of the predicate, e.g.

(22) [$_{\text{Path}}$ VIA ([$_{\text{Place}}$ ON ([$_{\text{Thing}}$ ___])])]
(e.g. *run across the bridge*)

(23) [$_{\text{Path}}$ VIA ([$_{\text{Place}}$ IN ([$_{\text{Thing}}$ ___])])]
(e.g. *float across the hall*)

(24) [$_{\text{Path}}$ VIA ([$_{\text{Place}}$ OVER ([$_{\text{Thing}}$ ___])])]
(e.g. *fly across the city*)

There is accumulating evidence that, independent of the status of such conceptual structures in a given linguistic theory, the [PATH [PLACE]] configuration is part of syntactic structure. Van Riemsdijk (1990: 236-237) provides convincing evidence of a higher functional layer in German PPs with circumpositions. In cases where there is a (lower) preposition and a (higher) postposition, only the lower lexical P may assign case, may subcategorize the DP, and may impose idiosyncratic selectional restrictions (among other distinctions). This structure is exemplified below in German.

(25) [$_{\text{FuncPP}}$ [$_{\text{LexPP}}$ [$_{\text{LexP}}$ hinter] [$_{\text{DP}}$ der Scheune]] [$_{\text{FuncPP}}$ hervor]]
behind the barn from
'from behind the barn'

Building on this analysis, Koopman (2000) makes the pivotal observation that all spatial Ps in the higher functional projection receive a PATH interpretation, whilst those in the lower projection are interpreted as PLACE. Cinque (1999: 138) points out that the same structural hierarchy can be found in English and Italian, with a 'grammatical P' in a lower projection:

(26) [$_{\text{PathP}}$ From [$_{\text{PlaceP}}$ out [$_{\text{P}}$ of [$_{\text{DP}}$ the darkness]]]]
(27) [$_{\text{PathP}}$ Da [$_{\text{PlaceP}}$ dietro [$_{\text{P}}$ di [$_{\text{DP}}$ noi]]]]
from behind of us
'from behind us'

In previous work (Stringer, 2005), I have suggested that this is precisely the structure for French prepositional phrases such as the following.

(28) Il est passé [$_{\text{PathPP}}$ par [$_{\text{PlacePP}}$ en dessous (du pont)]]
he AUX passed via LocP underneath (of.the bridge)
'He went under (the bridge).'

This analysis is also explicitly extended to Japanese by Ayano (2001) and Stringer (2005). The universality of the layered PP structure is further supported by the discovery that in languages that express notions of PATH and PLACE in extended spatial case systems, there is a strict hierarchy of PATH, PLACE and 'grammatical' affixes, which exactly mirrors the PP-internal hierarchy (Van Riemsdijk and Huybregts, 2001). In the example from Lezgian below, the oblique stem marker *-re* appears to mirror the role of 'grammatical Ps' such as English *of* and French *de*.

(29) sew-re-q^h –aj
bear-of-behind-from
'from behind the bear'

In their cross -linguistic survey, Van Riemsdijk and Huybregts (2001) note that in addition to notions of arrival and departure, some languages also encode the notion of VIA in exactly the same PATH slot, e.g. Innuit (Bok-Bennema, 1991), and Walpiri (Hale, 1996).

To return the issue of complexity, the above review leads to the conclusion that generative treatments of directional PPs, both semantic and syntactic, converge on the hypothesis that the various types of directional P may all be represented with the same two-tiered structure, with direction taking scope over location. It would appear that the relevant difference between predicates of traversal and other directional predicates lies elsewhere.

5.2 Spatial representations and directional predication

In a seeking a non-linguistic solution to the problem of the discrepancy between predicate types, perhaps the simplest alternative might be stated in terms of frequency. If it could be shown that the predicates expressing paths of traversal in each language (both Vs and Ps) are significantly less frequent in the input than all other directional predicates, it might be that this lack of sufficient exposure is responsible for the patterns observed in the data. Such being the case, children might have no problem with conceptualizing such events holistically, but rather have not yet formed strong enough associations between the relevant conceptual and phonological representations. However, given what is known about how children can 'fast map' new words with limited exposure (Carey, 1978b; Bloom, 2000), and given that the multiple predicate strategy persists until age 5 or 6, this seems an unpromising suggestion, and one I shall not pursue here. Rather, it seems plausible to posit that what distinguishes predicates of traversal (both V and P) from other directional predicates might lie in non-linguistic mental representations of these concepts. Differences between the meanings of items in the mental lexicon clearly go beyond those aspects that are relevant to syntax. A more viable approach might be to extend to the

domain of basic trajectories a theory of spatial representations that has already been convincingly applied in other areas of perceptual cognition, specifically capturing differences between related solid objects, and related manners of motion.

Attempts to formally distinguish between concept-pairs such as *chair* and *stool*, or *duck* and *goose*, have engendered considerable debate in the linguistics literature. Previous attempts to capture such differences by respectively positing linguistic features such as [±has a back] or as [±has a long neck] (along the lines of Katz, 1972), have generally been abandoned. Jackendoff has repeatedly argued that such information should be represented in an independent module of spatial representations (e.g. Jackendoff, 1987; 1990; 1997; 2002). Specifically, what is required is the kind of mental faculty proposed in work on visual cognition by Marr (1982), and elaborated by Biederman (1987). Marr's (1982) '3D model structure' is not simply a mental hologram, but an encoding of the geometric systems of spatial axes by which we organize our perceptions of objects; it represents the decomposition of objects into parts, and expresses the relations between these parts. It is not restricted to immobile objects, but can represent ranges of angles of attachment of parts, and other such parameters of variation. It is in this module of spatial representations that non-linguistic differences between these types of concept-pairs may be elaborated.[14]

Though it originated as a theory of object representation, Marr and Vaina (1982) advocate an extension of the 3D model to actions such as throwing and saluting. Jackendoff (1990: 34, 88-89) builds on this proposal by suggesting that this extended, animated 3D model may be precisely where differences between MANNER-of-MOTION verbs are articulated. For example, the differences in MANNER within the following sets of English verbs are conceptually significant but have no syntactic effects.

(30) a. throw, lob, toss
b. run, jog, lope
c. wiggle, spin, twist

The 'quasi-geometrical' format of spatial representations appears much better suited to capture such distinctions than the 'essentially algebraic' formats of syntax and conceptual structure (Jackendoff, 1990: 88). Predicates expressing trajectories such as *out*, *under* and *through* seem similarly ill-suited to differentiation in terms of linguistic features alone, and geometric distinctions between such concepts are necessary in any case. Assuming that the differences in meaning are more precisely differences in spatial representations allows for a rephrasing of the question of whether predicates of traversal have additional representational complexity: not in terms of features but in terms of representational geometry.

That the holistic conceptualization of events of traversal is more complicated than that of 'simpler' trajectories must necessarily be treated

speculatively within the confines of the present paper. However, it does seem plausible that that going to a place and stopping (either *at*, or *on* or *in* it), or starting from a place and leaving (either *from*, or *off* or *out* of it), are more basic kinds of representation. A combination of the two types of trajectory is necessary in order to derive a holistic, rather than a composite, journey to the far side. The data from this first language experiment provide groundwork for the hypothesis that children initially rely on composite spatial representations for such trajectories, as reflected in the multiple predicate strategy. The fine-tuning and testing of such a hypothesis remain matters for future research.

6 Conclusion

The same pattern of splitting paths of traversal into subevents was attested in the elicited speech of English, French and Japanese 3- to 4-year-olds, such that concepts of THROUGH and ACROSS were expressed in terms of entry and departure, or departure and arrival. This initial reliance on multiple predicates to convey such complex trajectories gradually gave way to holistic expressions, so that by age 6 or 7, utterances were essentially adult-like. This phenomenon cuts across language typologies, and holds irrespective of lexicalization in particular syntactic categories. Representative examples of utterances were provided to illustrate this consistent developmental pattern, and two hypotheses were considered. Whilst at first glance such results might appear to constitute corroborative evidence that complex lexical semantics can induce delays in the process of lexical acquisition, it was argued that predicates of traversal are no more linguistically complex than other directional predicates. A more promising line of inquiry was suggested in terms of non-linguistic representations, in an extension of '3D model structure' theory to basic trajectories through space. Given the serendipitous nature of these findings, a more targeted study would be required to fully investigate these impressionistic but intriguing patterns in lexical development.

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Notes

[1] For full discussion of this experiment, see Stringer (2005). The basic idea of using a picture story to elicit descriptions of motion events was drawn from work by Berman and Slobin (1994). However, the methodology, materials and goals differed from this influential work in several significant ways, due to a shift in focus from narrative styles to grammatical forms.

[2] Slobin's (1996) comparative study of English and Spanish motion events indicates that speakers of verb-framed languages may have a locational bias in event descriptions, elaborating on the environmental detail and leaving aspects of the trajectory to be inferred.

[3] All children were completely monolingual, having never been exposed to a second language. This was also the case for the English adults. Some French adults and all Japanese adults had studied English at school, but none were above beginner-level. The most important criterion was that no test subject's first language should be subject to influence from a second language, and this was unequivocally the case for all subjects.

[4] It is worth noting that in each language a number of children initially focussed on the MANNER of motion (e.g. crawling or swimming). If the initial utterance was a simple description of MANNER, this was not counted as a sub-event of the ensuing description. For example, the sequence <*il nage* / PROMPT / *il sort*> 'he swims / PROMPT / he gets out', was not counted as an instance of the child splitting the trajectory into two segments, but rather just as the child focussing on one sub-event (getting out).

[5] However, when comparing predicates in each language, it should be borne in mind that glosses are approximations; it should not be assumed that lexical items with identical glosses share either identical semantic representations or argument structures.

[6] Glosses include the following abbreviations: ACC - accusative; ASP - aspect; GEN - genitive; LocP - general locative adposition, translated as *at*, *in*, *on*, etc. according to context; PART - discourse particle; PROG - progressive; TE - Japanese TE-form, which has various functions.

[7] Japanese *moguru* means 'go under' with a GOAL interpretation, and is therefore only one sub-event. Use of the accusative is childlike in this context. Like *hairu* 'enter', *moguru* 'go-under (and stay there)' subcategorizes *ni* (LocP) in the adult grammar.

[8] The verb *kuguru* means 'go under and out the other side', and therefore lexicalizes the whole trajectory.

[9] A similar case could also be made for *under* and *over*, although the results were less pronounced.

[10] Whilst 2- and 3-year-olds say things such as 'big dog', and 'little mouse', children *do not measure* at this stage; thus the relevant notions expressed in utterances such as 'How tall is he?' and 'He's five feet tall' are beyond their ken.

[11] Of course, some individual adjectives (e.g. *big*, *little*) are mastered before others (e.g. *deep*, *shallow*), but the difference is not between positive and negative terms, so e.g. *little* comes before *deep* (Carey, 1978a).

[12] Gruber (1976: 12) makes clear that further analysis might prove such elements to be subject to further decomposition, in which case they may be read in his analysis as 'abbreviations'.

[13] In these examples, $_{B}\text{EXTENT}_{S/T}$ specifies a bounded extent of space or time, and POINT_{S} specifies an unextended point of space.

[14] The 3D model cannot be restricted to visual information. In their study on the acquisition of language by blind children, Landau and Gleitman (1985) stress the uncontroversial point that shape and location may be understood through touch as well as vision, and Landau and Jackendoff (1993) argue that proprioception must also be involved in constructing a mental representation of the body in physical space, as we reach for objects and navigate potential obstacles. Such a system of spatial representations cannot therefore be a 'Fodorian module'

in a strict sense, in that it is necessarily multimodal (Fodor, 1983; Landau and Jackendoff, 1993; Jackendoff, 1997).

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Appendix

The charts below show the proportions of utterances expressing (i) a whole trajectory in a single predicate or V^P combination; or a split trajectory with (ii) 2 or 3 sub-events or (iii) 1 sub-event. Subject groupings are coded by language (E: English, F: French, J: Japanese) and by age (3-7 in years, and A: Adult).

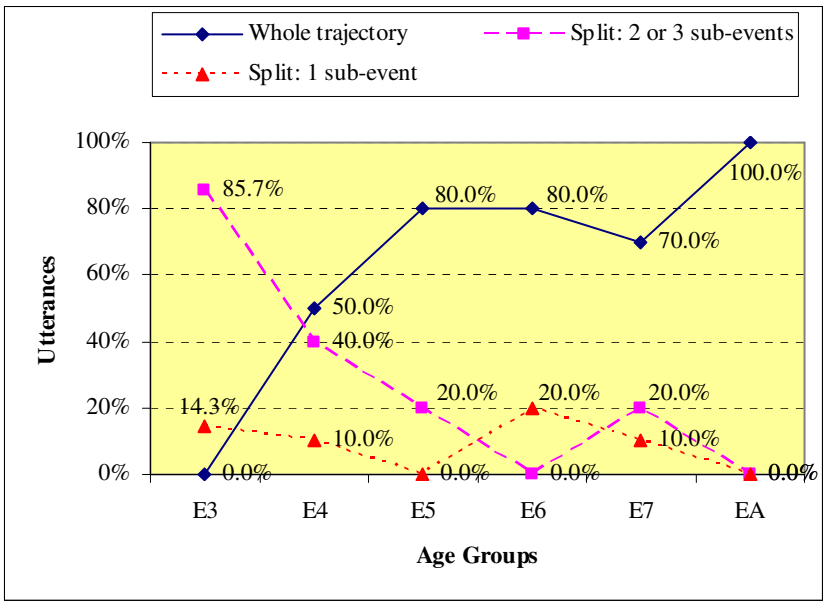

Figure 1. *English responses by age group: Splitting* THROUGH.

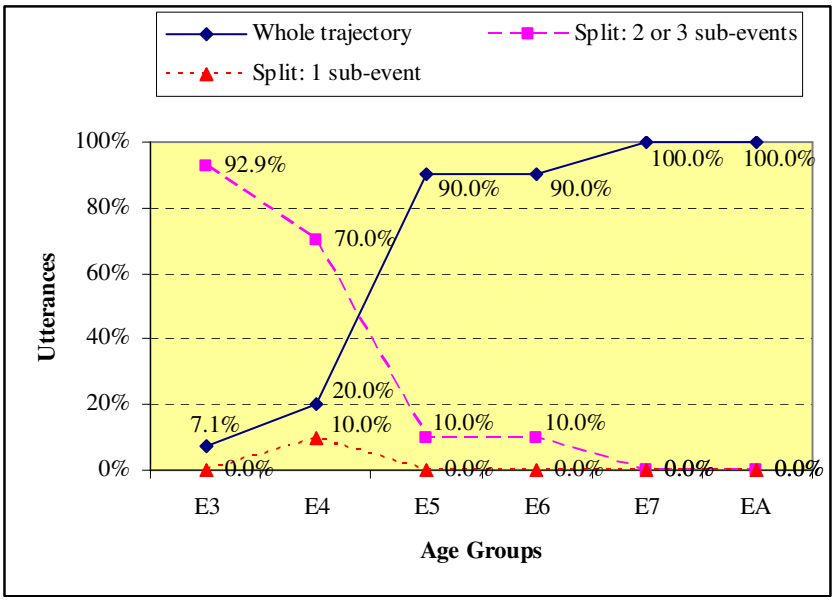

Figure 2. *English responses by age group: Splitting* ACROSS.

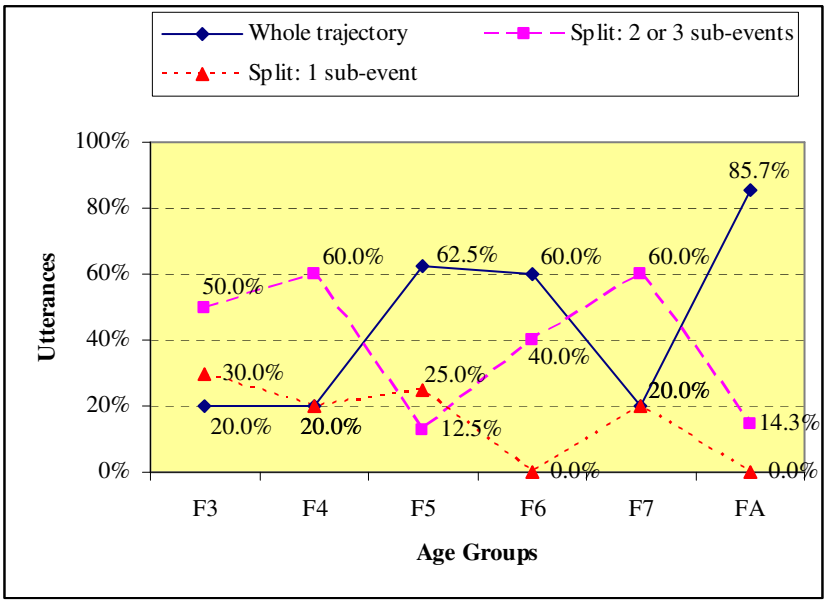

Figure 3. *French responses by age group: Splitting* THROUGH.

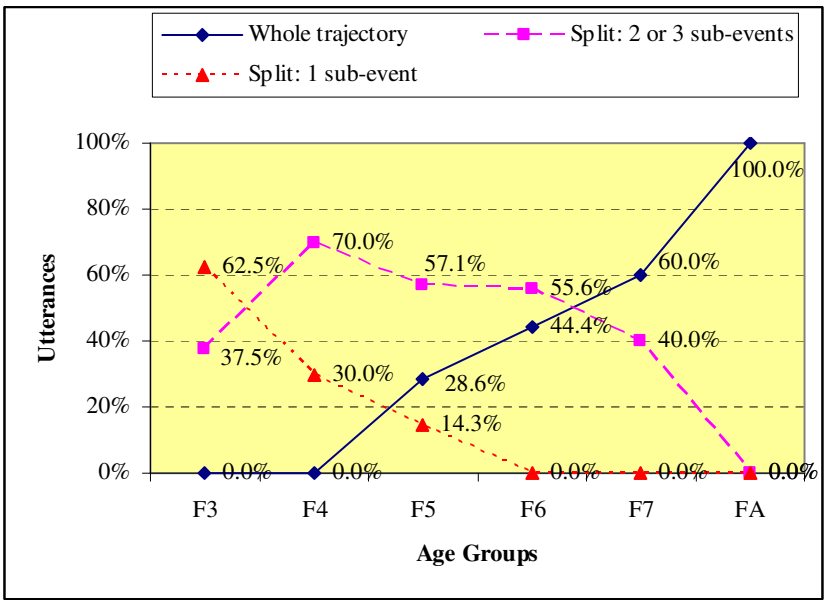

Figure 4. *French responses by age group: Splitting* ACROSS.

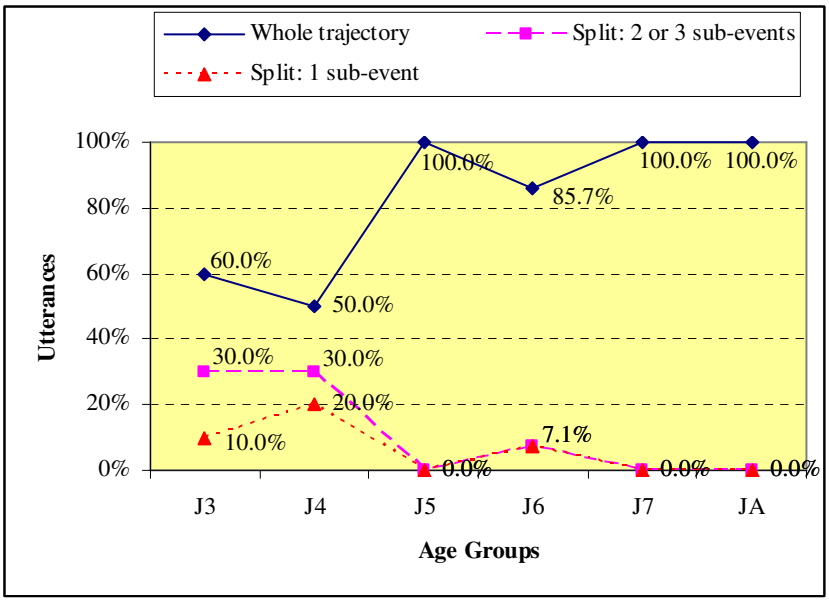

Figure 5. *Japanese responses by age group: Splitting* THROUGH.

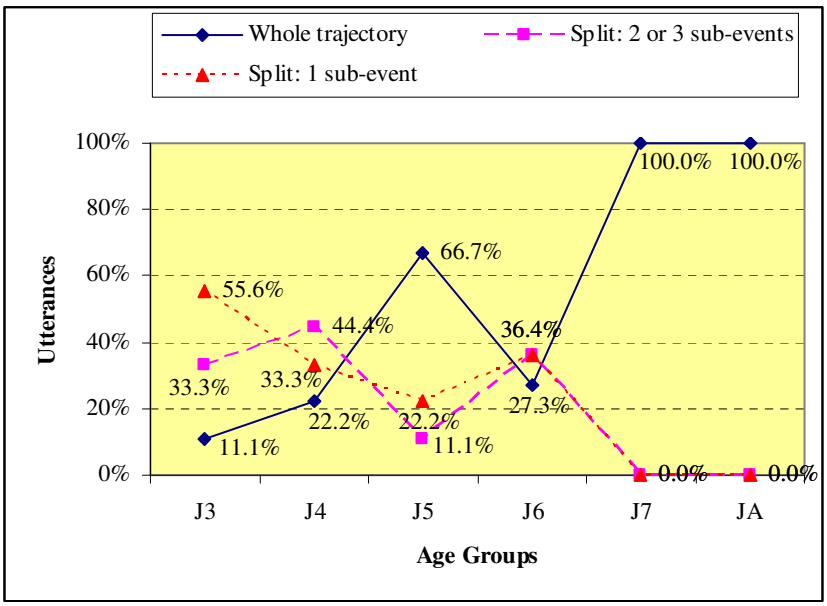

Figure 6. *Japanese responses by age group: Splitting* ACROSS.