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ABSTRACT

This study investigated (1) the order of acquisition of related temporal and spatial terms, (2) the application of temporal and spatial terms and (3) the relationship between the application of temporal and spatial terms and performance on cognitive measures of temporal and spatial ordering. Children 3 to 5 years of age were tested on four language tasks (two spatial and two temporal) and two cognition tasks. Spatial terms tested were: before, after, ahead of, behind, beside, together with, above and below. Temporal test terms were: before, after, together with, and at the same time as. The cognition tasks consisted of one test of seriation and one test of temporal ordering. Among the results, the comprehension of most terms improved with age. Before and after were found to be of about equal difficulty and the terms expressing simultaneity were acquired before terms expressing succession. The combination of after/before and before/after appeared to be the most difficult. It is concluded that both simultaneity and succession appear to be salient concepts for 3-year-old children. (Author/RH)

The Development of Relational Understandings of Temporal and Spatial Terms

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Abstract

The present study tested a number of predictions 1) concerning the order of acquisition of related temporal and spatial terms, 2) the prediction that when such terms are first acquired children are unable to apply them to more than one reference event/position, and 3) the prediction that the ability to apply temporal and spatial terms to two reference events/positions is correlated with performance on cognitive measures of temporal and spatial ordering. Children of ages 3-5 were tested for their comprehension of sets of temporal and spatial terms in tasks with 1 or 2 reference events/positions and were administered measures of temporal ordering and seriation. _Before_ and _after_ were found to be of about equal difficulty and the terms expressing simultaneity were acquired before the terms expressing succession. Some of the spatial antonym pairs showed better comprehension of the marked member of the pair while others showed superior performance on the unmarked member. The secondary dimensional term _beside_ was not acquired later than most primary dimensional terms. Prediction 2) was supported for temporal but not spatial terms. Prediction 3) was upheld only for the temporal construction showing the greatest dissonance between spoken order and meaning.

The Development of Relational Understandings of Temporal and Spatial Terms

A number of recent investigations of the relationship between semantic development and concept development have focused on the acquisition of temporal or spatial terms. Aside from their value in understanding semantic development, these studies also provide one of the best sources of information about the development of time and space concepts in early childhood currently available. The present study is intended to clarify three main issues raised by this research. The first main issue concerns the interrelation of various temporal terms or spatial terms during their acquisition and the relatedness of terms of the two domains. Previous investigators have frequently posited the existence of temporal and spatial semantic fields and assumed that their nature will be illuminated by studying the order of acquisition of conceptually related terms. In the temporal domain two sets of predictions were tested.

The first prediction derives from E. Clark's (1971) semantic feature theory of the acquisition of temporal terms. E. Clark hypothesizes that children learn the meanings of before and after by acquiring an ordered set of components of meaning. In her analysis the - Prior component underlying the meaning of after is acquired later than the + Prior component underlying the meaning of before. Of 10 comprehension studies with findings relevent to E. Clark's predicted order of acquisition of before and after, two indicate that before is an earlier achievement (E. Clark, 1971; Feagans, 1974, 3-year-olds only) while eight show a difference of less than 10% correct or that after is understood earlier (Amidon, 1976; Amidon and Carey, 1972; Barrie-Blackley, 1973; Coker,

1978; French and Brown, 1977; Friedman and Seely, 1976; Johnson, 1975; Ritter and Tuinman, 1975). These studies vary considerably in the age of subjects, task, syntactic construction, and likelihood of the event sequence, and each of these dimensions has been shown in one or more of the studies to be a significant source of variance. For example, in a recent paper Coker (1978) showed that the disparity in results in many of the studies can be attributed to variation in the syntactic form of the command and to apparent interpretive strategies used by the children. In Coker's study when a prepositional construction was used instead of the usual subordinate clause construction, the superiority of before disappeared. However, Coker's study is a limited test of Clark's hypothesis, since Coker's youngest subjects were 5-year-olds and E. Clark (1971) suggested that the semantic features of before and after were acquired between about 3½ and 4½ years. In another study 3-, 4-, and 5-year-olds were tested on two tasks in which before and after were embedded in sentences whose surface structure was similar to Coker's prepositional sentences. Friedman and Seely (1976) found no difference between the comprehension of before and after at 3 years or at all ages combined, even though in their tasks after should have been more difficult due to the order of insertion strategy (Clark, 1970). Even the 3-year-olds showed comprehension significantly above chance levels for before and after with these relatively simple tasks and commands. Since the finding of "no difference" between before and after is a negative one, it is important to replicate. In this study we tested comprehension of before and after using a task similar to one of Friedman and Seely's and using the same syntactic form, "John jumps in _____ Mary." It should be noted that in this task, as in Friedman and Seely's, memory demands are less than in many of the other previous studies, since the ordered events differ

in actor but not in the particular action. In light of the task and command simplicity of the present study and the young ages of the subjects, the results, like those of Friedman and Seeley, should be a relatively sensitive test of the predicted order of acquisition of before and after.

A second issue concerns the acquisition of temporal terms expressing the succession or simultaneity of two events. Piaget's work (1969) indicates that both succession and simultaneity are unstable concepts before age 8 or 9 years when temporal cues in a demonstration conflict with spatial cues (see also Levin 1977; Levin, Israeli and Darom, 1978; and Siegler and Richards, 1979), but his theory does not predict which of the two concepts is more primitive. However, E. Clark (1970) and Keller-Cohen (Note 1) do suggest that the concepts are sequentially acquired but advance oppdsite hypotheses. E. Clark (1970) claims, "The semantic properties of the subordinate conjunctions used in these constructions point to a general development of the concept of time, going from a recognition of the simultaneity of two events to the perception of an ordering relation between two events (p. 283)." This presumed order of acquisition is applied to semantic development in her feature analysis of the terms when, before and after (E. Clark, 1971). When is said to be unmarked for the feature "simultaneous" whereas before and after are both marked for this feature. On the other hand, Keller-Cohen (Note 1) advances the hypothesis that "sequence (precedes) simultaneity in language acquisition due to cognitive constraints on the child (p. 3)." Of six studies bearing on these hypotheses, two show terms expressing sequence better comprehended (Feagans, 1974; Keller-Cohen, Note 1), two show terms expressing simultaneity better comprehended (Amidon, 1976; Ginsberg and Abrahamson, Note 2), and two show no difference (Friedman and Seely, 1976; Kayra-Stuart, Note 3). These studies vary

in the age of subjects, the tasks, and the particular terms. Furthermore, in the analysis of succession-simultaneity differences in several of the studies, the author collapses across particular terms for succession or simultaneity. In the present study we attempted to test the developmental order, again using simpler commands and tasks than have been used in most of the previous studies on the assumption that this would lead to a more sensitive test of the hypotheses.

In the spatial domain, H. Clark (1973) proposed an analysis of space perception and space language which led to a number of developmental predictions. Two of these predictions are relevant to the present study. First, he claims that antonym pairs (e.g., ahead-behind) are conceptually asymmetric in that one member can be defined as a natural "positive" and the other a natural "negative". H. Clark predicts that positive terms will be acquired prior to their negative antonyms. The determination of the positive member depends upon a detailed analysis of the logical properties of space, but in each of the following pairs to be tested the former term is designated positive: before-after, ahead of-behind, above-below. Second, he suggests that certain terms (e.g., beside) refer to a "secondary dimension" which must be defined with respect to a "primary dimension", such as above-below or front-back. H. Clark predicts that terms referring to secondary dimensions will be acquired after terms referring to primary dimensions. Previous studies of spatial relational terms have failed to support the predicted order of acquisition of antonym pairs (Friedman and Seely, 1976; Kuczaj and Maratsos, 1975), but Kucazj and Maratsos' finding that side was understood at later ages than front or back supports H. Clark's (1973) second prediction. The present study tests each of these predictions and includes the terms above and below which were not tested in the other two studies.

A final prediction concerning sets of spatial and temporal terms is made by H. Clark (1973). He assumes that temporal conceptions are based on spatial conceptions and concludes that "...spatial expressions should appear before time expressions and, in particular, each term that can be used both spatially and temporally should be acquired in its spatial sense first (1973, p. 57)." While there is support from the production studies cited by H. Clark that children use locative terms earlier than they use temporal terms, there is no reliable evidence supporting his claim that temporal conceptions are based on spatial conceptions. Comprehension studies of terms with joint spatial and temporal reference have shown that many of the terms appear to be acquired first in their temporal sense. Friedman and Seely (1976) tested several terms described by H. Clark (1973) as temporal terms derived from a spatial metaphor. They found that before and after are better comprehended in their temporal senses while behind was better understood in its spatial sense. Two other terms, first and last, were also better understood in temporal tasks. Feagans (1974) also showed that before was better comprehended temporally at three years but found no difference between the spatial and temporal senses of after. The present study provides an additional opportunity to test Clark's prediction.

The second main issue arises from the observation that young children often produce responses to spatial and temporal relational terms which, while appearing correct, actually suggest a more limited understanding of the terms than is true for adults. In the case of temporal terms, Coker (1978) noted that in one task her subjects responded to 10% of the sentences calling for two actions by performing only a single action. Friedman and Seely (1976) observed similar behavior in their study, though this was not reported. For example, their subjects often responded to sentences such as "John gets up

before Mary" by making only John get up. These responses may indicate that the relational nature of the terms is less salient for young children than for adults. It may be that early meanings of terms like before or after connote an absolute temporal position, such as "first and only" or "end of the sequence". One way to test for relational understandings of temporal terms is to use more than one reference event. Coker (1978) used a procedure in two of her tasks in which children responded to questions including the terms before or after by making judgments about a memorized three event sequence. All six possible relations were tested. Over 60% of the 5½-year-olds made at least one error with one or the other prepositional sentence construction. A comparison of the performance of Coker's 5½-year-olds with that of Friedman and Seely's (1976) 5-year-olds on a different task with a single reference event suggests that before and after are responded to somewhat more accurately when children relate one event to another than when they judge relationships in a three event sequence. A more direct comparison can be made in the present study between term comprehension for two and three event sequences, since comparable tasks and the same children will be used.

Several studies suggest that the early comprehension of spatial terms may also fail to reflect the relational nature of the understanding of older children and adults. For example, Kuczaj and Maratsos (1975) found that children between 2½ and 4 years could point to the fronts and backs of various fronted objects at an earlier age than they could place a standard in front of or in back of the objects. It is possible that even the children who succeed on the standard placement task are simply extending their understanding of inherent fronts and backs to include contiguous space. Windmiller (1976) proposed a similar interpretation, using Piaget and Inhelder's (1956) distinction

between topological and projective space, to account for certain of her findings. In addition, a number of studies (Elkind, 1961; Laurendeau and Pinard, 1970; Piaget, 1928) of the comprehension of the terms left and right have shown that the ability to apply these terms to the relative position of three objects is a later achievement than the ability of the child to identify his inherent left and right or those of another person facing the child. In the present study we will attempt to distinguish relational from positional understandings of the terms before, after, above and below by contrasting performance on a task with 1 reference position with performance on a task with 2 reference positions.

The third main issue concerns the relationship between the understanding of temporal and spatial terms and the development of space and time concepts. Several researchers have reported positive relationships between performance on time or space language tasks and tests of concepts in the same domain (Weil, 1970, cited in Beilin, 1975; Windmiller, 1976) or general cognitive development (Ferreiro and Sinclair, 1971). In this study we assumed that the abilities contributing to a relational understanding of temporal and spatial terms such as before and after in the case of 3 events/objects are akin to those of non-linguistic tasks that require the child to relate the time of an event to earlier or later ones or the length of a stick to larger or smaller ones. For this reason each child was administered tests of seriation and temporal ordering in addition to the tests of spatial and temporal relational terms.

Method

Subjects

Two groups of subjects were tested: (1) 13 3-year-olds ranging from 3-5 to 4-2 with a mean age of 3-9, and (2) 12 5-year-olds ranging from 4-10

to 5-10 with a mean age of 5-6. The younger group had 7 females and 6 males, and the older group had equal numbers of each sex. The subjects were recruited from 2 private nursery schools and a public day care center. Only children whose parents gave consent were included. Three 3-year-olds refused to participate.

Procedure

Children were tested individually by 2 experimenters, one of whom administered the procedure while the other scored responses. After learning the names of 3 dolls, Snoopy, Linus and Lucy, children were invited to play some games. The testing procedure consisted of 4 language tasks (2 temporal and 2 spatial) and 2 cognition tasks. On each of two days children were tested on one temporal language task, one spatial language task and one cognition task. Given these restrictions, tasks were randomly assigned to sessions and ordered within sessions. Occasionally, the procedure was distributed over more than 2 sessions when children seemed to lose interest.

Insert Figure 1 about here

A plexiglas apparatus (see Figure 1) was used for both spatial tasks, 2 doll (S2) and 3 doll (S3). Each of 5 levels consisted of an array of circular slots into which the doll bases fit. In S2 a single reference doll, Lucy, was positioned in the center slot of level 2. On trials in which the test word implied a response on the horizontal plane, Lucy faced toward the child's right or left. On trials in which a vertical axis response was correct, Lucy faced the child. The differential orientation of the reference doll may have inadvertently helped children distinguish vertical

from horizontal items, but there is no obvious reason why one set or the other would have been made easier by this cue. Before testing began the experimenter showed most of the possible placements of the Snoopy doll and encouraged the child to show others. During the test trials subjects manipulated the Snoopy doll, placing it in response to each test sentence. The form of each S2 sentence was, "Snoopy is _____ Lucy." The terms tested were before, after, ahead of, behind, beside, together with, above and below. Each term was tested twice. The first occurrence of each term was randomly placed in the first half of the set and the second occurrence in the second half of the set. Each test item was scored as correct or incorrect, and for each error the placement of the Snoopy doll was recorded. If a subject failed all the items in the first half of the set, the second half was deleted, and the deleted items were scored incorrect.

In S3 both Linus and Lucy were used as stationary reference dolls. On horizontal-correct trials the reference dolls were placed along the left-right axis of level 2 in the 2 slots adjacent to the center slot, and both faced to the left or right of the child. Thus, the horizontal planar responses included before, after and between both dolls and beside the center slot. Nonhorizontal planar responses were also possible. On vertical-correct trials Linus and Lucy were placed in the center slots of level 2 and level 4 facing the child. If a correct interpretation of a sentence required either Linus or Lucy to be placed ahead of or above the other, the reference dolls were arranged accordingly. Test sentences were of the form, "Snoopy is _____ Linus/Lucy and _____ Linus/Lucy (other doll)," for the combinations before before (befbef), after after (aftaft), before after (befaft), above above (abvabv), below below (belbel) and below above (belabv). For the terms between (with vertical orientation of

the reference dolls, betver) and between (with horizontal orientation of the reference dolls, bethor) sentences were of the form, "Snoopy is _____ Linus and Lucy (or Lucy and Linus)." Each combination was tested twice with the order of mention of the reference dolls reversed. Possible vertical and horizontal responses were modeled or elicited prior to testing, and scoring was similar to that of the S2 task.

The 2 event temporal task (T2) and the 3 event temporal task (T3) used 2 uncovered square plastic food containers, one of which was inverted, to suggest a swimming pool and diving deck. In T2 only Snoopy and Lucy were placed on the deck. In T3 all 3 dolls were used. Before each task the experimenter demonstrated the possible sequences in which the dolls could jump in the swimming pool and both or all of the dolls jumping in simultaneously. For T2, sentences were of the form, "Snoopy jumps in _____ Lucy," and the test terms were: before, after, together with and at the same time as. Each term was tested 3 times (in order to make the assumed probability of being correct on all trials for a term by chance responding comparable to that of the other tasks).

T3 sentences were of the form, "Snoopy jumps in _____ Linus/Lucy and _____ Linus/Lucy (other doll)," for the combinations: before before (befbef), after after (aftaft), before after (befaft) and after before (aftbef). For the terms together with sentences took the form "Snoopy jumps in _____ Linus and Lucy (or Lucy and Linus)." The latter sentences differed syntactically from the former set but seemed more natural. Each term or combination was presented twice with the order of mention of the reference dolls reversed. Responses on T2 and T3 were scored as correct or incorrect and the nature of the errors was recorded. For each of the spatial and temporal tasks individual subject's correctness scores on each term could be treated as proportion correct

or dichotomized into the categories: consistently correct or at least one error. The assumed probability of consistently correct performance for each term by chance alone could be derived from the number of possible alternative responses and the number of repetitions. This was computed to be $p < .05$ for each term in each task.

The cognition tasks consisted of 1 test of seriation and 1 test of temporal ordering. The seriation task is derived from Elkind's (1964) modification of Inhelder and Piaget's procedure and is described in Friedman (1977). The seriation score (SerYev) ranged from 0 to 6 depending on the child's ability to reconstruct a modeled ordering by length of 14 wooden sticks. The temporal ordering task was Friedman's (1977) daily activities test (DA). DA score ranged from 0 to 3 depending on the child's success in ordering cards depicting familiar daily activities (waking up, eating breakfast, working at school, playing outside, eating dinner and sleeping at night). One point was awarded for a correct ordering of 4 cards, 2 for this plus subsequent correct insertion of an additional card and 3 for a correct initial ordering and the correct insertion of both additional cards.

Results

The comprehension of most terms improved with age, as shown by significant correlations between age in months and proportion correct. The following terms failed to show a significant correlation with age, Pearson r's < .34, p's > .05: spatial-*together*, *above*, *belabv* and temporal-T2 *together*, *same time*, *befbef* and *befaft*.

Insert Table 1 about here

Table 1 shows that there is considerable variation in the difficulty of individual terms, as measured by the number of children showing perfect performance.

Acquisition of Related Terms

Specific predictions about the order of acquisition of related terms were tested by performing repeated measures t-tests on the proportion correct scores. Mean proportion correct as a function of age is shown for each task in Table 2. In the temporal domain, E. Clark (1971) suggested that before is understood

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Insert Table 2 about here

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prior to after and that the latter would initially be misinterpreted to mean the former. Neither prediction was supported in the present study. The two terms had nearly identical overall means. The slightly higher mean of before for the 3-year-olds did not differ significantly from that of after. In addition, the error data shows that "before" responses to the term after were even less frequent than "after" responses to before (11 out of 23 errors for the former vs. 15 out of 24 errors for the latter). A second set of comparisons of the T2 terms suggests that the terms for simultaneity are better understood than those for succession and that the latter are of about equal difficulty. Only 2 significant differences were found: together with is better understood than before and after with the age groups combined, t's (24) > 2.42, p's < .03. Terms expressing simultaneity are not easier simply because performing the actions at the same time is a general default response to noncomprehension, since simultaneity responses constituted only 30% of the errors for the terms before and after versus 56% antonym responses.

In the spatial domain, H. Clark (1973) predicted the acquisition of before, ahead of and above before their antonyms and the acquisition of this whole set before the term beside. None of these predictions was supported. First, after was slightly better understood than before overall, though this difference was not reliable. Behind was significantly better understood than ahead of, $t(24) = 3.36$, $p < .01$. Above was better comprehended than below, but this difference was not significant. Even the slight superiority of above may be attributable to a tendency of children who don't understand a term to produce an "above" response. Thirty-seven percent of the errors for the terms before and after consisted of putting the Snoopy doll above Lucy. Such non-linguistic response strategies have been found in other studies and are discussed by E. Clark (1973, 1974, 1975). Second, comprehension of beside was not the latest achievement of the set. Beside only differed significantly from 3 S2 terms: It was more poorly understood than behind, $t(23) = 3.10$, $p < .01$, but was better understood than before and after, t's $(24) > 2.30$, p's $< .04$.

H. Clark (1973) predicted that terms which could be used both spatially and temporally would first be understood in their spatial sense, and that comprehension of temporal terms in general would emerge later than that of spatial terms. There was no support for either prediction. Table 3 shows a comparison of terms or combinations which can be used both temporally and

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Insert Table 3 about here

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spatially. Of the 5 comparisons showing significant differences 4 displayed temporal priority and 1 spatial priority. An examination of S2 and T2 terms

in Table 1 indicates that the acquisition of spatial and temporal terms is a concurrent process, since some spatial terms are better understood than the temporal set whereas others are more poorly understood. There is some risk inherent in comparing performance levels from different tasks as is done above, since the tasks are not pure measures of temporal and spatial competence. However, it is reassuring that performance levels for the best understood term in each task are comparable (Tables 1 and 2).

Effect of Multiple Reference Events or Objects

We found support for the prediction that temporal terms would be more difficult to apply to 3 event tasks than to 2 event tasks. Several comparisons between T2 terms and T3 combinations (Table 2) were performed. First, proportion correct scores for individual subjects were pooled for the T2 terms before and after and divided by 2 and compared to mean scores for the 4 T3 combinations divided by 4. The former index showed higher levels of comprehension than the latter, t (24) = 4.14, $p < .01$. The T2 terms expressing simultaneity were not significantly different from together with in T3, and all 3 had similar means. A comparison of individual T2 terms with corresponding T3 combinations showed that aftaft was more poorly understood than after, t (24) = 2.16, $p < .05$, whereas before and befbef had identical overall means. However, there is some reason to suspect that the befbef scores overestimated the competence of some children, since 57% of the errors on aftaft, befaft and aftbef consisted of making the Snoopy doll jump in before the 2 reference dolls. This response should account for less than 17% of these errors if responding were due to random ordering. Such responding may represent a kind of "order of mention" strategy (E. Clark, 1970, 1971) in that Snoopy was always

mentioned first. Aftbef and befaft appeared to be the most difficult terms of either the temporal or spatial sets. They were significantly more poorly understood than befbef, aftaft and the T2 succession terms. Table 2 shows that at 3 years understanding of aftbef and befaft is very poor, and at 5 years correct performance is common only for aftbef, which differs from befaft in the fact that the order in which the reference dolls act is concordant with their order of mention in the instruction. The difference at 5 years between aftbef and befaft is significant, t (11) = 3.53, $p < .01$.

The effect of two reference objects on the comprehension of spatial terms was less clear. A comparison of terms in S2 with related combinations in S3 indicates that double reference is more difficult for some spatial terms but not for others. Two of a possible 4 comparisons showed significant differences. After is better understood than aftaft, t (23) = 2.85, $p < .01$, and above is better comprehended than abvabv, t (23) = 2.89, $p < .01$. Below and belbel approached a significant level, t (23) = 2.00, $p < .06$, whereas before and befbef have nearly identical means. Of the antonym combinations, aftbef actually appeared to be easier than before, after, befbef and aftaft, though only the last difference is significant, t (23) = 2.70, $p < .02$. However, the superiority of aftbef may be due to yet another instance of a response bias of subjects who do not understand a sentence: 41% of the errors for befbef and aftaft consisted of placing Snoopy between the other dolls. The other antonym combination, belabv, appeared slightly more difficult than below and somewhat more difficult than above, but neither difference was found to be reliable. Belabv appears easier than abvabv or belbel at 3 years and harder at 5 years, but none of these differences is statistically significant. Again, a response bias may have led to overestimation of this

antonym combination, since the "between vertical" response accounted for 35% of the errors for the combinations abvabv and belbel.

Two terms in S3, betver and bethor, were not related to specific hypotheses. Betver was significantly better comprehended than befbef, aftaft, and belbel, and bethor was responded to more accurately than aftaft. However, each of these differences may be confounded by the apparent response biases previously mentioned, that favor placing Snoopy between the reference dolls.

Relationship to Indices of Concept Development

Both Serlev, Pearson r (23) = .68, $p < .01$, and DA, r (23) = .53, $p < .01$, are correlated with age. At 3 years 85% of subjects failed to order at least 4 items in either task, whereas at 5 years 75% met this criterion on Serlev and 58% met it on DA. Serlev and DA are correlated without, r (23) = .67, $p < .01$, and with, partial r (22) = .50, $p < .01$, age controlled, replicating Friedman's (1977) finding with 4- to 10-year-olds.

Many terms were fairly well understood at 3 years at which age few children could seriate or order the cards in the DA task. The order of acquisition of the linguistic and cognitive measures could be statistically tested by dichotomizing Serlev and DA (plus or minus correct ordering of at least 4 items) and term comprehension scores (plus or minus perfect performance) and examining cross tabulations of the cognitive indices with each term. If more subjects succeeded on one index and failed on the other than the reverse, then the former would be a prior achievement. Binomial tests were performed on the off diagonal cells with alpha = .05, two tailed, as the significance level. The following terms preceded Serlev by these criteria: S2 behind, T2 together with, T2 same time, T3 together with and one term, T3 befaft, followed it. Nine terms preceded DA: S2 ahead, S2 behind, S2 beside, S2 above,

S3 betver, T2 before, T2 together with, T2 same time and T3 together with. T3 befaft was a later achievement than DA.

With the exception of betver and the temporal simultaneity items, none of the instances of terms preceding the cognitive measures are double reference. However, while many of the double reference items show considerable progress between 3 and 5 years when Serlev and DA are improving markedly, there is little evidence for specific correlations between the cognitive indices and the comprehension items. Most of the total set of 25 terms and combinations were significantly correlated with DA and/or Serlev (30 out of 50 possible), but only 2 such relationships remained at significant levels when the common variance attributable to age was partialled out. S2 before, partial r (22) = .50, $p < .01$, and T3 befaft, partial r (22) = .40, $p < .03$, were significantly related to DA with age controlled (and with age and Serlev controlled). In the 5-year-old group T3 befaft was significantly correlated with DA, Pearson r (23) = .57, $p < .03$. These data give little support to the predicted relationships between S3 items and seriation and between T3 items and temporal ordering performance. Only one item, T3 befaft, showed correlations consistent with the prediction.

Discussion

Several predictions were tested concerning the relation between individual temporal and spatial terms during their acquisition. The pattern of results for the temporal terms does not support either E. Clark's (1971) semantic feature analysis of temporal terms or Keller-Cohen's (Note 1) hypothesis that the concept of succession is acquired prior to the concept of simultaneity. E. Clark's model is consistent with the finding that terms

for simultaneity are better understood than those for succession but cannot account for the apparent concurrent acquisition of before and after or the failure to show more "before" interpretations for after than the reverse. Since the conclusion that before and after are concurrent acquisitions is based in part on a "no difference" finding, and negative findings of this sort have unknown reliability, it is desirable to find confidence limits for the difference in comprehension scores. In finding these limits we restricted consideration to children under 5;0, since the inclusion of older children who understand both terms would lead to an underestimate of comprehension differences that may exist during acquisition of the terms. In order to achieve a sufficient sample size we included 3- and 4-year-olds from three separate studies: Friedman and Seely (1976), the present study, and a subsequent unpublished study by the author. In all three studies before and after were embedded in sentences similar to those of T2. While these commands have the advantage of relative simplicity of surface structure, it should be observed that they also introduce a bias of unknown magnitude in favor of E. Clark's (1971) prediction, since the meaning of all after sentences violates the order of mention of the actors. The analysis of the proportion correct of 55 subjects showed the mean superiority of before and 95% confidence limits to be .04 $\pm$ .12. An alternative nonparametric analysis revealed that 17 children had superior comprehension scores for before, 14 for after, and 24 had equal scores for both. In light of the contradictory findings of previous studies and the evidence presented here, it seems reasonable to conclude, with Coker (1978), that before is not regularly acquired prior to after.

A second finding of the present study was the greater comprehension of terms expressing simultaneity than terms expressing succession. These results

appear consistent with those of Amidon (1976) and Ginsberg and Abrahamson (Note 2) but inconsistent with those of Feagans (1974) and Keller-Cohen (Note 1). These studies are heterogeneous with respect to age of subjects, terms, syntactic form, and tasks, and it seems likely that the obtained developmental sequence depends upon each of these factors. By restricting consideration to those studies in which the whole sample consisted of 3- to 5-year-olds or 5-year-old's performance was reported separately, we can draw some conclusions about what 3- to 5-year-olds know about terms expressing succession and simultaneity. Taken together, the data of Feagans (1974) and Amidon (1976), who used similar sentence forms, indicate that _when_ is understood better than _before_ and _after_, but _while_ is much more poorly understood than these terms. In the present study _together with_ and _same time_ showed higher comprehension scores than _before_ and _after_. It appears that there are marked differences in the difficulty of individual terms for simultaneity with _while_ being a harder form than _together with_, _same time_, and _when_. Though Keller-Cohen (Note 1) does not present the individual term scores separately, it is likely that her finding of superior performance on succession terms may be due in part to including _while_ in her simultaneity set and including two apparently easy forms of succession, _and then_ (see E. Clark, 1970) and _first_ _____, _last_ _____ (Amidon and Carey, 1972) in her succession set.

The most important conclusion from the present data, coupled with the findings of Feagans (1974) and Friedman and Seely (1976), is that both simultaneity and succession appear to be salient concepts for three-year-olds when assessed by means of the comprehension of particular terms. Furthermore, the term variability that has apparently led to conflicting findings is troublesome for a semantic feature analysis of temporal terms, since such an analysis

should predict developmental sequences that are general across terms. It is similarly troublesome for Keller-Cohen's (Note 1) claim that sequence precedes simultaneity in language acquisition. Finally, from a methodological point of view, the present study indicates that comprehension tests that require the child to perform two actions are not insensitive measures of simultaneity, as Ginsberg and Abrahamson (Note 2) suggest, if the actions can easily be performed at the same time.

The present study failed to support H. Clark's (1973) predictions concerning the acquisition of spatial terms and his spatial metaphor model of the development of temporal understanding. Terms considered by H. Clark to be positive were not consistently better comprehended than their antonyms, nor did beside appear to be a later achievement than many primary dimension terms. The latter result suggests that Kuczaj and Maratsos' (1975) finding that comprehension of on the side was achieved later than in front of or in back of should not constitute support for a general distinction between primary and secondary spatial dimensions. In fact, even within the set of terms tested there were differences between terms for the same spatial relationship. Behind was easier than after, and ahead of was easier than before. Such differences between terms for the same relationship indicate that factors other than adult meaning contribute to the age at which particular terms are acquired. In the case of before and after infrequent use by adults in the spatial sense may be a limiting factor.

Another factor that appears to influence the age of acquisition of spatial terms is the ease with which directional terms can be assimilated to the names of inherent parts of the reference objects. If we supplement the data of our 3-year-olds on S2 with those of Kuczaj and Maratsos' (1975) group III (which

had a mean age and ranges within 2 months of our group) on their frontal object placement task, we find that 3 terms have comprehension scores considerably greater than the rest of the set and have means of nearly identical magnitude, mean proportion correct: in front of .87, in back of .87, and behind .89. The former 2 terms have obvious inherent part referents, and Kuczaj and Maratsos showed that the ability to identify the intrinsic front and back of objects was an earlier achievement than the analogous relational responses. Less obvious, perhaps, is that children use behind to refer to the inherent posterior of various animate objects. It appears, then, from the present data and those of Kuczaj and Maratsos that directional terms which derive from inherent object parts can be accurately responded to by 3-year-old children, whereas other directional terms may require an additional year or 2 to reach high levels of performance. "Inherent part terms", as used in our discussion, should not be confused with H. Clark's (1973) "intrinsic prepositions", since the former are only a subset of the latter.

More direct support for the precedence of inherent part terms comes from a subsequent unpublished study by the author. Twenty five 3- to 5-year-olds were tested on a comprehension task similar to the S2 task of the present study. Terms from two sets were presented in random order. The set of inherent part terms included in front of, in back of, behind, on top of and on the bottom of. The set of relational terms included before, after, ahead of, above and below. The mean comprehension score was greater for the set of inherent part terms than for the relational terms, $t(22) = 5.28$, $p < .01$. Both sets showed significant age improvement between three and five years, F's $1,20; 1,21 > 10.00$, p's $< .01$.

Comparison of individual spatial terms also indicates that directional axes, though frequently assumed in discussions of the concepts underlying spatial language, may be alien to the young child's understanding of particular terms. If the child constructed his understanding of spatial terms from a single axis running through the front and back of objects we would not expect to find assymetry between the understanding of behind and ahead of as we did. Finally, the findings of the present study, like those of Friedman and Seely (1976), show that the temporal understanding of a number of terms with joint spatial and temporal reference is not a later achievement than the analogous spatial understandings. Only the antonym combination aftbef was comprehended at an earlier age in its spatial sense. The reasons for this difference will be discussed below. H. Clark's (1973) spatial metaphor model has been previously evaluated in light of contradictory evidence (Friedman & Seely, 1976) and will not be discussed here.

The results discussed above illustrate the difficulty of making accurate developmental predictions from the logical or linguistic analysis of adult language. The development of young children's ability to understand particular spatial and temporal terms appears to be influenced by factors such as the frequency of adult use (Dunckley and Radke, Note 4), contextual support for interpretation (as in inherent part terms), as well as the still poorly understood development of early space and time concepts. It is even clearer that performance in comprehension studies is subject to the interaction between task features, such as the complexity of stimulus sentences and required responses, and children's response strategies, such as responding in the order of mention (Clark, 1971), deleting the subordinate clause (Amidon and Carey, 1972), or responding with the next event in time (Coker, 1978).

An additional pair of predictions was that when temporal and spatial terms are first acquired they cannot be understood in relation to more than a single reference event or object. The temporal prediction was confirmed. Before and after were consistently correct for more than half of the children, whereas aftaft, aftbef and befaft were consistently understood by fewer than 40% of the subjects. Befbef was scored consistently correct for about half of the children, but the true level of understanding was probably augmented by a tendency of noncomprehending subjects to make the doll first mentioned act before the others. The limited nature of young children's ability to convert sentences using these relational terms into ordered actions is most evident in the case of befaft. Befaft sentences required the production of an order of action which was dissonant with both the temporal placement of the standard doll and with the relative order of the reference dolls in the instructions. These sentences were consistently understood by only 2 children. It appears that temporal features of the spoken sentences can help or hinder children's acting out the meaning of the instructions. This factor seems most potent when the memory demands of sentences are greatest. In previous studies, Ferreiro and Sinclair (1971), using a sentence production task, and Amidon (1976), Barrie-Blackley (1973), E. Clark (1971), Coker (1978), French and Brown (1976), and Hatch (1971), using comprehension tasks, have shown similar interference effects when the spoken order of actions is dissonant with the intended order.

The results pertaining to the spatial prediction were less clear. Some spatial terms appeared better understood in the single referent task than the double referent task, whereas others did not. Comparisons between individual terms in their single and double reference uses within individual age groups

can be interpreted as showing that certain spatial terms are acquired late but once acquired can be applied equally well to single and double reference contexts. This pattern may be obscured in comparisons in which the 2 age groups are combined. Table 2 shows that the understanding of both before and after are late achievements, but within the 5-year-old group the terms are about equally well comprehended in each context. Below appears to show similar age trends, but the term above does not. The 3-year-old group responded correctly to above on about two thirds of the trials but only responded correctly to abvabv on about one third of the trials. However, it is possible that response biases inflated above scores to a greater extent than abvabv scores. Thirty-four percent of the errors on S2 tasks other than above consisted of placing the standard doll above the reference doll. Only 18% of error responses on S3 tasks other than abvabv consisted of placing the standard above the uppermost reference doll. If above does fit the pattern of before, after and below, and this is by no means clear from the present study, then the distinction between inherent part terms and relational terms, made above, may predict not only order of acquisition but also range of application once acquired. It may be that the relational terms are acquired later than the inherent part terms but shortly after acquisition can be applied equally well to single and double reference contexts.

The difference between aftbef spatial and aftbef temporal, previously mentioned, appears paradoxical, since both befbef and aftaft are understood earlier in their temporal applications. The aftbef comparison seems to indicate that spatial relational understandings are achieved before temporal relational understandings, whereas the befbef and aftaft comparisons are consistent with the reverse developmental order. However, we have noted that

a response bias in S3 may have favored "between" responses, and that the factor of word order in the stimulus sentences contributed to interterm variability in T3. Given these measurement problems it does not appear possible to resolve the question of priority of spatial or temporal relational understandings of before and after from these data.

The correlational analyses did not show a consistent relationship between lexical comprehension scores and time or space concept measures. Performance on the temporal and spatial relational tasks, T3 and S3, improved substantially between 3 and 5 years, at which ages the temporal ordering and seriation scores increased as well. But only one of the double reference items showed a significant correlation with the concept measure of the same domain when age was statistically controlled. Befaft temporal shared specific common variance with the temporal ordering index, DA. It is interesting that of the temporal combinations, befaft sentences had the greatest dissonance between the order of articulation of the actors and the intended order of action. This dissonance precluded mediating representations based on repetition of parts of the stimulus sentence such as were apparent in several of the older children. Five-year-olds occasionally rehearsed the temporal order aloud before responding. For example, following an aftbef sentence they might say, "Okay, after Linus and before Lucy." In order to perform successfully on befaft sentences, some other means for representing temporal order must have been used. The correlation between befaft and DA suggests that the ability to represent these more difficult sentences is related to the ability to represent the temporal order of events in a hypothetical daily sequence. Two previous studies have tested the relationship between time language and time concepts or cognitive development. Weil (1970, cited in Beilin, 1975) found a significant correlation between

a joint index of temporal vocabulary and syntax and a composite index of several time concept tasks. However, comprehension of the terms before and after was not clearly related to performance on a task that required the child to order pictures of temporal series (e.g. leaves falling off trees). The latter result is similar to our own finding that T2 terms were not specifically related to DA. Ferreiro and Sinclair (1971) report a relation between the ability to conserve liquid and the ability to produce sentences with temporal connectives that preserve the true order of events. Unfortunately, the data are not presented, and one is not able to rule out the possibility that the common variance is attributable to age changes alone. In general, there is little evidence that the child's temporal understanding of the terms before and after in a single reference context is related to the ability to order several pictures in a temporal series. It should be noted, however, that neither Weil's study nor the present experiment compared the ability to order as few as 2 pictures with the understanding of before and after. Second, the time concept measure used in this study cannot predict the comprehension of before and after in 3 event sequences, except in the special case in which the order of mention of the standard doll vs. the reference dolls and the order of mention of the one reference doll vs. the other were dissonant with the semantic order.

There was no evidence for specific relations between seriation and the comprehension of the spatial terms. Windmiller (1976) has shown a significant association between the comprehension of spatial relational terms in a single reference context and performance on a different Piagetian spatial task, tactile to visual matching of shapes. But her analyses did not show whether there was common variance beyond that attributable to age. The evidence of

the present study and Windmiller's indicate that the development of spatial relational understandings is an achievement concurrent with progress on certain Piagetian spatial tasks, but it is not sufficient to show that knowledge of a child's performance on these tasks gives us a greater ability to predict comprehension of spatial terms than does knowledge of the child's age alone.

The correlational analyses of the present study and two previous studies mentioned illustrate the limited kind of information that can presently be obtained from relating performance on temporal and spatial cognitive and semantic tasks. Almost certainly we will need a more detailed knowledge of spatial and temporal concepts and semantic development before we can clarify the relationship.

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Table 1

Number of Subjects Meeting the Criterion of Perfect Performance for Each Term or Term Combination

S2 N=25		S3 N=24[a]	
Behind	22	Betver	15
Above	17	Bethor	13
Beside	17	Belbel	13
Together	16	Abvabv	12
Ahead	15	Aftbef	12
Below	15	Belabv	12
After	12	Befbef	9
Before	10	Aftaft	8

T2 N=25		T3 N=25	
Together	19	Together	19
Same Time	19	Befbef	13
Before	16	Aftaft	9
After	14	Aftbef	6
		Befaft	2

[a]One subject was not administered this task.

Table 2

Mean Proportion Correct for Each Term or Term Combination by Age

Spatial							
	S2				S3		
	3	5	Mean		3	5	Mean
Behind	.89	1.0	.94	Betver	.46	1.0	.71
Above	.65	.88	.76	Bethor	.35	.86	.58
Beside	.54	.96	.74	Belbel	.19	1.0	.56
Together	.58	.88	.72	Abvabv	.35	.95	.63
Ahead	.46	.96	.70	Aftbef	.38	.81	.59
Below	.38	.92	.64	Belabv	.46	.73	.58
After	.39	.71	.54	Befbef	.27	.68	.46
Before	.27	.71	.48	Aftaft	.08	.68	.35
Mean	.52	.87	.69	Mean	.32	.84	.55

Temporal							
	T2				T3		
	3	5	Mean		3	5	Mean
Together	.85	.95	.89	Together	.70	1.0	.84
Same Time	.80	.92	.85	Befbef	.62	.75	.68
Before	.54	.83	.68	Aftaft	.38	.66	.52
After	.47	.92	.69	Aftbef	.08	.67	.36
				Befaft	.08	.21	.14
Mean	.66	.90	.78	Mean	.37	.66	.50

Table 3

Summary of Repeated Measures T-tests between Temporal and Spatial Uses of the Terms or Combinations Which Have Temporal and Spatial Reference

Term or Combination	Better Understood Use	p for 3 yr. olds	p overall
Before	Temporal	.05	.02
After	_____	n.s.	n.s.
Befbef	Temporal	.01	.04
Aftaft	Temporal	.02	n.s.
Aftbef	Spatial	.05	.05
Together[a]	Temporal	.05	.04

[a] In S2 and T2 only.

Figure captions

Figure 1. Apparatus used in S2 and S3 tasks.