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ABSTRACT

This study explored children's development of a "mental time line" and considered the propositions that younger children view the temporal domain as bi-polar, while older children display signs of using finer gradations on their mental time ruler that approach conventional structures of clock and calendar time. Subjects were a group of Sydney (Australia) children aged three to six years attending day care, with 20 children in each age group (3,4,5,6 years giving a sample size of 80). Children were asked to identify something that "happened a long time ago," something that is "going to happen a long time from now," something that "happened a little while ago" and something that will "happen in a little while." Results suggested that older children were more likely to give valid responses to the questions. For each pair of questions (long/short time in past; long/short time in future), valid responses were compared to determine if events cited differed appropriately in their distance from the present. There was a strong tendency for 3-year-olds to give examples to pairs of recall and prediction questions that came from the same "place" on the temporal ruler, with this tendency diminishing markedly after 3 years of age. Older children showed signs of more finely divided temporal rulers and greater mastery of markedness. The use of conventional ways of time measurement and of naming temporal locations and intervals was unusual, but usage increased with age. Precise location of events using conventional terminology was more frequent for recent versus distant events. There was increased differentiation of the past and the future with increasing age. (KDFB)

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Casual observations of children's use and comprehension of everyday temporal terms reveals that young children do not understand time concepts as adults do. Of the many cognitive skills which children must master in order to become proficient members of their cultures, the acquisition of commonsense time concepts is among the most essential but probably one of the least thoroughly researched.

Unpacking the skills required to use basic temporal concepts soon reveals that this everyday ability is extremely complex. Understanding the process of its acquisition requires knowledge of how adults conceptualise time, and of cognitive development in a number of areas, notably the mastery of the symbolic systems of language and mathematics.

How do we understand 'time'? As with all abstractions time is often described metaphorically. Metaphor allows some abstract entity to be likened to a concrete experience or set of experiences and described in the language of reassuringly physical fact. The particular metaphor used to describe time is space and the language of time is replete with words lifted directly from the spatial domain (Lakoff and Johnson, 1980). Events happen before or after one another, the party is next Saturday is 'coming up', seemingly approaching us, or we are 'getting close to Christmas', travelling towards it through some metaphorical space.

As a brief aside, parents and other carers 'instinctively' understand children's difficulty with time concepts and use various strategies to help the child understand

their implications for activities. An example of this is the use of 'number of sleeps' as an indication to when an event will occur - 'We are going to visit Grandma and Grandpa after three big sleeps'. This example also illustrates the use of 'big' and 'little' as descriptors of time intervals, rather than long or short. Piaget (1969) noted that children confound size with age but this is understandable when parents and other carers refer to 'big enough to go to school' or 'too little to go to the shops alone' instead of 'old enough' and 'too young'. Again, this shows a good intuitive grasp of the facts of the acquisition of abstract concepts for it uses what is in effect a physical metaphor to describe an abstract quantity - size = age, and by extension, physical size = temporal extent.

The use of the particular metaphor, that time = space, has many implications for the way time is experienced and conceptualised (Lakoff and Johnson, 1980; Herbert Clark, 1973, E. Clark, 1979; Clark and Clark, 1977). As with space, time as a domain is also measurable and again the language used reflects the 'spatialisation' of time - for instance time intervals can be long or short. Linguist Herbert Clark (1973) has described how the properties of physical space come to be perceived also as the properties of 'time' space. He discusses a framework for understanding the socially constructed dimensions of perceptual space, both physical and temporal, based on the concept of reference points and rulers.

For any length, temporal or otherwise, to be measured there must be a defined beginning and end point. Temporal durations may extend forward into the future or backwards into the past, using 'now' as the implicit reference point. Other starting and ending points may also be specified. For example both the beginning and the end of the interval may be in the past, or a currently continuing event or process may have commenced in the past and consummation be expected in the future. These points are what Clark calls the 'primary' reference points.

'Secondary' reference points are the benchmarks established by expectation about when an event or process should begin or end, and thus how long it should continue. There exist different 'rulers' for different situations and activities, so that what constitutes a long time on one occasion is reckoned short on another. There is a possibility that, viewed developmentally, 'secondary' reference is actually primary, at least as it relates to an individual's experience of an event. The ultimate measure of whether an event is too long or short is the expectation of the person involved.

When duration and extent into past or future are discussed, then, there is a hierarchy of meanings. An individual is required to understand the implied primary reference points and the actual clock or calendar time involved, the specific ruler that applies and what is the expected commencement time, extent and completion time. There is also the personal experience of the event to be considered so that even an experience that conforms to social expectation in all its temporal specifics, can seem to an individual to take for ever to start or to finish. Or time can fly when one is having fun. Length of time is thus far from being a simple concept and mastering the every day art of conversing on event duration requires considerable sophistication and some not small experience in the use of a host of 'rulers'. Young children can be forgiven for finding being told they have to wait a 'long time' for something they want an unsatisfactorily vague piece of information.

Other aspects of the mastery of related concepts will also affect the acquisition of the language of time, most importantly the rules which govern what is known as 'markedness' (Clark, 1973). Pairs of words which describe the poles of a dimension, for example 'young-old', 'long-short', 'beautiful-ugly' always consist of one term which is unmarked and one which is marked. The unmarked term is the one which is generally descriptive of the dimension - in the examples given we speak of length, not shortness, so long is the unmarked term, whilst short is the marked term. Similarly we say that someone is so many years 'old', not 'young' (except when joking with a nonagenarian aunt), so old is unmarked. Developmentally, the unmarked term is acquired first which has implications for the acquisition of time concepts. Children will have facility when dealing with conversations which feature 'how long' measures of time before those which contain references to 'short' or similar measures.

Time itself is said to be 'assymetrical' in a similar fashion in that developmentally the past and its measurement and classification is mastered before the future for the good and sensible reason that the past has happened is available for recollection and mental inspection whereas the future has not and is not. Some asymmetry in the ability to construct mental rulers for the past and future may thus be expected.

The Development of Numeric Skills.

Research into the development of number skills has added further insights as to how Clark's concepts of 'rulers' may have wider application to the investigation of children's understanding of many cognitive domains. Neo-Piagetian theorists such as Siegler (1976, cited in Griffin, Case & Siegler, 1994) suggest that significant changes occur between the ages of four and six in children's ability to measure and quantify. Four years olds tend to represent quantities as global or bipolar, so that 'big' things are worth more than small ones with no gradations in between. However, by six, children have added subdivisions to their mental rulers so that there is a continual gradation of values between the two poles.

Resnick (1983, cited in Griffin, Case & Siegler, 1994) has employed Siegler's ideas to further explore young children's intuitive understanding of number and arithmetic. Use of the mental number line allows children to make judgements about whether one number is bigger or smaller than another and to solve simple mental arithmetic problems. Other theorists have suggested that mental number lines are not unique to the numeric domain however, and that development of the ability to quantify has effects across all domains that are dimensionally structured. Griffin, Case and Siegler (1994) report that evidence has been found of a 'dimensional structure' in many cognitive domains, including moral reasoning and social reasoning, which have an 'implicit quantitative component'.

Mastering Time Concepts.

It possible to see the acquisition and organisation of the cognitive map that represents the temporal 'realm' as being the mastering of a symbolic system with an obviously dimensional structure ('rulers'). General trends in the comprehension and utilisation of mental number lines, or in this case time lines, should be discernible in children's understanding of the structure of time and the meaning of conversational time terms.

The trend towards the development of a 'time dimension' characterised by continuous gradations should be reflected by an increasing ability with age to 'place' events on the mental time line relative to one another. The past and present, representing the two poles of the time line would also be expected to be perceived as undifferentiated by younger children, but older children should be able to discriminate between intervals of varying lengths and to more easily nominate events

which occurred or will occur at longer or shorter distances from the present. However this development will be mediated by the parallel acquisition of mastery of marked-unmarked terms and of the 'asymmetry' of aspects of human temporal experiences. Finally, the ability to use conventional time tools, such as calendars and clocks, would require a well defined mental time line which would allow for appropriately placed and labelled gradations/intervals. Correct use of calendar and clock terms then would be evidence of possession of a mental time line which approaches or has achieved adult degrees of sophistication.

The aim of the current research is to begin to explore the development of the temporal 'mental time line' and to investigate whether the rules of development found to describe children's intuitive understanding of other cognitive domains characterised as quantifiable dimensions can be applied to their ability to understand and use common time concepts. Specifically, it explores the propositions that younger children will view the temporal domain as bi-polar whilst older children will display signs of using finer gradations on their mental time ruler which approach the conventional structures of clock and calendar time.

Method.

Participants.

The subjects were a group of Sydney children aged from three to six years. There were 20 children in each age group (3, 4, 5, 6 years) giving a sample size of 80. Most were residents in an inner western suburb of mixed socio-economic status and were the clients of either of two long day care centres, one in an inner city suburb and one associated with a university, or attended one of two schools - a state infants school in the inner west, or an independent progressive school on the north shore.

The two long day care centres serviced a clientele of mixed socio-economic status with a proportion of children from non-English speaking backgrounds. There was probably some bias towards the higher income brackets, however, because of the locations of the two centres. Both centres offered programs designed to stimulate the children's development and the day-to-day activities featured a strong educational component.

The two infants schools serviced a largely middle class clientele but differed markedly in their educational philosophies. The public school was very structured and offered traditional subject matter, traditionally taught. The progressive school

featured a much more 'child centred' environment with an emphasis on discovery learning and much less explicit teaching of concepts and subject matter.

Procedure.

Information was collected via a structured interview consisting of four short questions

1. Can you tell me something that happened a long time ago?
2. Can you think of something that is going to happen a long time from now?
3. Can you tell me something that happened a little while ago / just happened?
4. Can you think of something that will happen in a little while?

Participating children were interviewed at their school or day care centre. The interviews were kept brief and followed a short period of general conversation to establish rapport. The questions were presented in the same order for each subject. If a child answered 'don't know' to an item they were prompted first with the original wording. If they still could not answer they were prompted again with the alternative wording presented above. A third null response was accepted as the best likely under the circumstances. All answers were recorded verbatim on pre-typed answer sheets. Tape recording not used as it had been found to be distracting for younger children. Taking down the responses by hand proved not difficult because answers were usually brief.

Results.

Responses on each of the questions were first coded as null or valid, that is whether the child could or could not give a valid response. Ability to give a valid response to each question in itself is a measure of understanding of the concepts conveyed. Table One contains the percentages of children from the four age groups who could not give a valid response to each question. The results show the expected trend of increasing understanding with age, that is decreasing tendency to give a null response, on each question.

Table One: Percentage of children from each age group who gave a null response to each question.

Question		Age 3	4	5	6	
1.	Something from a long time ago		20	15	10	0
2.	Long time from now		60	50	20	5
3	Something from a little while ago		15	25	10	0
4.	Little while from now		35	25	10	0

For each pair of questions (long/short time in the future; long/short time in the past) valid responses were compared by subject to ascertain whether the pairs of events differed appropriately in their 'distance' from the present. If they did, the paired responses were coded as 'correct'. Tables Two (a) to Two (d) contain examples of pairs of responses assessed as 'same' or 'different', by age categories. Table 3 presents the numerical results for this analysis.

Table 1

(a) Examples of responses to pairs of recall questions classified as 'not different'.

Age	Ques	Example
3	1	He lost his foot, one of the kids on the road.
	3	The man was crossing the road.
4	1	A flood.
	3	A rock fell on a chair.

(b) Examples of pairs of responses to recall questions classified as 'different'.

Age	Ques	Example
3	1	When I was a tiny baby and I was going to grow up.
	3	When I was starting to play 'Snakes and Ladders'. (<1 hour)
4	1	The olden days.
	3	Gareth took his army off the table. (<1 hour)
5	1	When I was a baby and I started walking.
	3	Pete was silly. (same day)
6	1	Mummy was born.
	3	Gemma was born. (8 weeks previously)

(c) Examples of pairs of responses to prediction questions classified as 'not different'.

Age	Ques	Example
3	2	When I get big and don't suck my thumb any more.
	4	It's getting summer.
4	2	My grandpa is going to wake up.
	4	My friend's house is going to get breaked into.
5	2	They're going to start special electric trains.
	4	The electric trains might start going.
6	2	Going to ballet.
	4	I'm going to ballet.

Table One (cont'd)

(d) Examples of pairs of responses to prediction questions classified as 'different'.

Age	Ques	Example
3	2	I'm going for a holiday.
	4	I go to bed.
4	2	We are going on a plane to England.
	4	I'll go home [from preschool].
5	2	It's going to be Christmas.
	4	My school is going to have a full dress rehearsal this coming Monday.
6	2	I would turn 31.
	4	One of my friends is going to turn 4 in a few weeks.

Table Three: Percentage of responses which involve different temporal intervals, by question pairs and age.

	Age				
	3	4	5	6	Total
Question pairs					
Long time/little time ago 58	91	100	100	90	
A long/little time from now	40	56	81	95	80

Table Three shows that there was a strong tendency for the 3 year olds to give examples in their answers to the pairs of recall and prediction questions that came from the same 'place' on the temporal ruler, usually near in time. This tendency diminished markedly after age 3. Older children thus showed signs of more finely divided temporal rulers as well as greater mastery of markedness, so that they were able to give pairs of answers which were appropriately differentiated when asked for events 'a long time' or 'a little time' from the present.

Comparisons of the answers to questions requesting events from the far and near future and past throw some light on the issue of the nature of the rulers children were using to measure time intervals, and whether primary (or social/normative) or secondary (egocentric/personal) reference is being employed. Use of conventional

time terms (clock/calendar terms) was taken to mean movement towards mastering 'working' time concepts and a more adult like temporal 'ruler'. Table Four contains the percentages of children who used conventional time terms to help 'place' the events that they nominated in response to the questions.

Table Four: Percentage of children of each age group using of conventional terms in response to the questions.

Question	Age 3	4	5	6
1. ('happened long ago')	0	10	15	25
2. (happen a long time from now)	0	5	15	25
3. ('happened recently')	0	15	25	45
4. ('will happen soon')	5	0	20	20
Total (number of occurrences)	1	6	11	26

Use of conventional ways of measuring time and naming temporal locations and intervals is unusual amongst the children in this study. Usage, however, increases with age (from 1 occurrence amongst 3 year olds to 26 amongst six year olds). This was as predicted. Precise location of events using conventional terminology was more frequent for recent events than for more distant ones. An example of a response that suggested the subject was well on the way to mastery of adult style 'rulers' was, (from a six year old to a request for an event from a long time ago) 'The first night of last year when my dad's car got broken into'.

The large number of potential reference points and rulers summonsed by questions which feature terms such as 'a long time' has been discussed and it is plausible that even adults faced with these questions would choose examples using idiosyncratic criteria. Analyses of the questions thus required taking of their essential vagueness into account and the confounding effects on answers of the acquisition of social definitions of long and short times (secondary reference) by older children. To investigate the relationship between age and the characteristics of rulers the data was first content analysed to give 'distance' categories and responses to each question were then tabulated by age group and examined for signs of greater differentiation being associated with increasing age.

Events nominated as happening 'a long time ago' were classified using a five way typology (a) < 1 year. (b) 1-2 years. (c) Own infancy. (d) Before one's own birth (e) Distant past.

Table Five: Probable time since each nominated event by age group for Question 1, 'a long time ago'.

Question (%age valid N)	Age 3	4	5	6
1.< 1 year	69	29	24	10
2. 1-2 years	15	18	18	45
3. Own infancy	8	0	24	30
4. Before s's birth	8	18	6	10
5 Distant past	0	35	29	5

Whilst the results produced should be viewed with caution as the pattern produced could be an artefact of the 'scaling' used, the trend apparent is of increasing differentiation of the past. For most three year olds, any event remembered from the past happened 'a long time ago', whilst many four year olds in this sample had apparently discovered historical/prehistoric time as a concept suggesting that they divided the past 'ruler' into approximately two regions - recent personal past and a very long time ago. Thus many of four year olds' answers feature events which hail from the 'olden days' and the era of the dinosaurs. Four and five year olds show a wider temporal 'spread' in the events which they choose, suggesting that their 'rulers' now have become more detailed, allowing them a more comprehensive range of 'long times ago' from which to choose.

As similar analysis was performed on the answers to question 2 - something which will happen in a long time from now and again a five way typology for classifying answers was constructed (a) less than a year from now, (b) 1-2 years, (c) participant's own later childhood or adolescence, (d) later in life cycle, (e) distant future.

Table Six: Probable time to each nominated event by age group for Question 2, 'will happen in a long time'.

Question (%age valid N)	Age 3	4	5	6
1.< 1 year	86	40	56	30
2. 1-2 years	0	30	25	30
3. Later ch'hood	0	0	0	15
4. Later lifecycle	0	10	19	15
5 Distant	14	20	0	10

A similar pattern to that found on the previous question is discernible in the results in that increasing age is associated with choices from a wider range of temporal realms. Again, four to five year olds show signs of having recently discovered the far distant future as a concept and four year olds especially appear to organise distant future time using two 'divisions' on the temporal ruler - a very long time in the future and not so long in the future.

Children's responses to the 'short time' questions reveal a similar pattern of development to that seen in the previous two sets of results. Responses to Question 3, 'something which happened a little while ago', were coded using 6 categories - (a) Same day; (b) Same week; (c) Same month; (d) Same year; (e) More distant; (f) Indeterminate.

Table Seven: Probable time since each nominated event by age group for Question 3, 'happened a little while ago'.

Question (%age valid N)	Age 3	4	5	6
1. Same day	54	47	50	50
2. Same week	30	6	28	20
3. Same month	0	24	6	10
4. Same year	0	6	16	15
5. More distant	8	0	0	5
6. Indeterminate	8	17	0	0

Results again show a greater temporal 'spread' for the older children as compared to the younger.

Answers to Question 4 were coded using six categories (a) Same day. (b) Same week. (c) Same month. (d) Same year. (e) More distant. (f) Hope it's soon (the latter referred to anticipated events such as birthdays and Christmas).

Table Eight: Probable time until each nominated event by age group for Question 4, 'will happen in a little while'.

Question (%age valid N)	Age 3	4	5	6
1. Same day	54	66	35	40
2. Same week	30	0	6	20
3. Same month	0	17	29	20
4. Same year	0	0	12	5
5. More distant	8	17	12	5
6. Hope it is soon	8	0	6	10

Again, the results suggest a widening of temporal horizons, increased access to social definitions of temporal concepts and increasingly finer gradations on the temporal ruler as children's age increases.

Discussion.

Features of the answers given suggest that even these relatively young children were able to understand the questions as put and to be moving in the direction of understanding the finer points of conversational time concepts. As an example, for all ages the temporal domain of 'a little while ago' was narrower than that of 'a long time ago', whilst older children showed definite signs of were more likely to give pairs

of answers to 'opposite' questions (long time/short) which differed in the appropriate ways.

Despite the possible confounding effects of the other developmental cognitive and linguistic processes described in the introduction, the results of the study confirm the prediction that children's developing understanding of conversational time terms would share features common to development in all cognitive domains which are characterised by mental rulers, that is, are dimensionally structured. The youngest children tended to give answers which indicated relative undifferentiation of the dimension, being 'clumped' at a similar place on the temporal ruler. The next discernible stage of development was, as predicted, a move at around four, to a bi-polar characterising of the domain, followed by increasing differentiation amongst the five and six year olds.

Given that the development of facility with time terms follows those of other dimensionally structured domains Resnick's suggestion that many difficulties with a variety of cognitive tasks have their origins in failure to master the mental number line could be further explored in the context of temporal concepts. It may be possible, when developmental milestones in the domain are properly mapped and normed, to test the proposition that children with delays in this area are those who also show signs of problems in the development of the mental number line. Such a relationship if proven would indicate that there exists a way to remediate difficulties in a number of cognitive domains with one set of interventions designed to address a generalised problem with dimensionally structured concepts.

The research should be regarded as exploratory and the extent to which the results could be generalised may be affected by the restriction of the sample to children of English speaking background from mostly middle class families. In common with much psychological research this study has taken age as a defacto measure of developmental level and future research might gainfully control for actual developmental level to allow for the precise mapping of stages of development in this particular domain.

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