CHILDREN'S DURATIONAL ORGANIZATION OF EVEREYDAY EXPERIENCES: A MATHEMATICAL PERSPECTIVE OF A LINGUISTIC STUDY

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How do children reason about the durations of daily experiences? Following Tillman and Barner's (2015) linguistic study, three children (age five, six, and seven) were asked to organize four everyday activities from the shortest duration to longest duration: watching a movie, brushing their teeth, sleeping at night, and eating lunch. After creating their "timeline", each child was asked why they ordered the events as they did. By allowing the children the opportunity to reflect on common experiences and explain how they reasoned about durations, we can begin to recognize how children understand time as a quantity. Their responses showed that reflections on lived durational experiences were heavily influenced by physical acts, such as speed of actions or movement of the sun. These findings were consistent with past research on children's conception of physical time (Long & Kamii, 2001; Piaget, 1969).

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Tillman and Barner (2015) presented a series of linguistic experiments to explore young children's development of durational language. Through these experiments, Tillman and Barner theorized that children hear and use durational words, such as minute and second, but are unable to define these words with precise meanings, such as a minute being made of 60 seconds. The authors' asserted, "a lag [exists] between production and comprehension of duration words" (Tillman & Barner, 2015, p. 58), a point that would be supported by mathematics researchers and educators (Earnest, 2015; Harris, 2008; Kamii & Russell, 2012; Piaget, 1969). Thus, Tillman and Barner's research does not seem to lie solely within the field of linguistics, but also mathematics education research.

Durational words are commonly used in everyday English, for example, a parent telling their child "just a second" or "hang on a minute". During casual conversation these durations are not used as quantified elapsed time intervals, but rather are used as informal estimates of general wait times (Tillman & Barner, 2015). How such informal intervals are understood and used by children is an underrepresented area in mathematics education research. The value of such research would be to establish what temporal conceptions elementary students might bring with them to the mathematics classroom prior to formal time instruction.

Theoretical Framework

Currently, the Common Core State Standards Initiative (CCSSI) places time instruction within the Measurement and Data strand beginning in first grade. According to Common Core, first graders are taught to, "Tell and write time in hours and half-hours using analog and digital clocks" (CCSSI, 2020). There are no precursory standards that establish children's understanding of what hours and minutes are, so it could be inferred that the creators of Common Core believe these durational conceptions are either unimportant or unnecessary for clock reading and time telling, or already known prior to first grade (age six).

This lack of prerequisites seems counter to how Common Core has structured other forms of measurement. According to Common Core, kindergarteners should be able to, "Describe measurable attributes of objects, such as length or weight" (CCSSI, 2020) and, "Directly compare two objects with a measurable attribute in common" (CCSSI, 2020). These standards are addressed prior to learning the tools for such measurement. In other words, kindergarteners are explicitly taught about

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length-based attributes before being taught how to use the tools to measure them. For example, a kindergartener is taught to compare two lengths of string in order to tell which is longer. This comparison is intended to later bring about strategies for measuring, such as aligning starting points or considering left-overs—both of which are important to consider when measuring time (D. Earnest, personal conversation, May 27, 2019).

Unlike measuring lengths, where quantities can be physically compared against one another as described by the Common Core standards, measuring duration requires the creation of a hypothetical, iterable unit (Piaget, 1969).“The only method of [creating a “mobilized” durational unit] is to reproduce the physical phenomenon whose course (motion) was [the] duration” (Piaget, 1969, p. 67). So, when making judgements about the duration of common experiences, an individual must mentally reconstruct their experience, then dissociate time from perceptive influences, such as effort, emotion, or velocity.

The mental process of distinguishing time from spatial influences is referred to as the operationalization of time (Piaget, 1969). To construct *operational time*, one needs to coordinate succession (the consecutive sequence of events) and duration (the intervals of and between events). This, unlike *intuitive time*—which is based on spatial perceptions—means the individual understands time is continuous, homogeneous for all individuals, and uniform in its measurement (Russell, 2008). For example, a child who conceived of time intuitively would believe that as they walked faster, time moved faster. When reasoning operationally about time, this child would know that their actions have no impact on the duration of their experience.

Piaget (1969) contended that children were able to reason operationally about time by the age of nine (around fourth grade). Long and Kamii (2001), however, found it was not until sixth grade (around the age of 11) and Russell (2008) argued that it was not until eighth grade (around the age of 13). Irrespective of which of these studies might demonstrate an accurate age for the operationalization of time, none place the necessary reasoning for time measurement at first grade (age six), as described by Common Core (CCSSI, 2020) and Tillman and Barner's (2015) study. I hope this study may begin illustrating how children in the early elementary years think about duration based on their lived experiences.

Methodology

This multiple case study (Yin, 2003) followed a modified investigation from Tillman and Barner's (2015) *Experiment 3*, which explored how children placed familiar events on a figurative “timeline”. During *Experiment 3*, Tillman and Barner asked children, age five to seven, and adults, to place whole numbers, everyday experiences (e.g., watching a movie, washing hands), units of time (e.g., seconds, hours), and timed durations (e.g., four minutes, two hours) on an open number line. Participants were not asked about their reasoning for their placements, instead a quantitative analysis was completed on each age group.

To understand how children might reason about different durations from reflections on their daily experiences, I asked three children (age five, six, and seven) to organize four activities from shortest to longest amount of time, following the last study of *Experiment 3*. Each child was asked to reflect on why they arranged the events as they did, so that I could complete a qualitative analysis.

Participants and Procedure

To represent the same youth population used by Tillman and Barner (2015), three children: Kris (age five), Sam (age six), and Casey (age seven) were interviewed. All three participants were from the same elementary school in a large suburban city in the western United States. Each child, and their parents, consented to participate in this interview, as part of a larger study on how children reason about durational experiences.

Kris, Sam, and Casey were video, and audio recorded during one-on-one interviews. The interview protocol was modified from Tillman and Barner's (2015) *Experiment 3*. Each child was given four cards with pictures and words of common activities: watching a movie, brushing their teeth, sleeping at night, and eating lunch. These activities slightly differed from those used in *Experiment* 3 in order to better relate to the sample population. Each child was asked to arrange the cards along a continuum from what took the shortest amount of time to the longest amount of time. After completing their "timeline", each child was asked to explain why they organized the cards as they did.

Following each interview, field notes were taken, and each interview was transcribed. Transcripts captured words, hesitations, and actions of each child. All transcripts were member checked by the child and their parents prior to analysis.

Data Analysis

Given the exploratory nature of this research, and the open-endedness of the responses, I used a constant comparison analysis (Glaser & Strauss, 1967). Reasonings were coded inductively, then codes were compared to note any similarities, differences, or apparent progression between and across participants.

The focus of this analysis was not on the accuracy of the child's organization, but rather the durational reasoning presented during their explanation. For example, Casey, age seven, ordered the events: brushing teeth as the shortest duration, then sleeping at night, then eating lunch, then finally watching a movie as the longest duration. This order was not the same as either of the other two participants, nor was it accurate by the actual average length of each activity. However, Casey's explanation displayed a different interpretation of what sleeping at night meant, which explained how her durational order made sense.

After initial coding, themes were created, hypothesizing possible attributes being attended to during the three children's durational reasoning, such as effort exerted, standard units of time, and physical indicators of passing time. These themes were compared against previous studies of children's conceptions of time.

Findings

Tillman and Barner's (2015) quantitative results showed that children in all three age groups (five, six, and seven years old) performed fairly poorly when organizing the durations of common events. The authors' asserted that given these results, "it seems highly unlikely that children's learning of the rank ordering of duration is mediated by knowledge of the approximate durations of events (e.g., that children learn 'an hour' by mapping it to events described as 'an hour', and noting the duration of those events)" (Tillman & Barner, 2015, p. 68). In other words, when children organize familiar experiences, it does not seem that they are using an understanding of the actual duration of each activity.

Through the interviews, I found that at some point, each of the three children explained their sequence of events using standard durational units (e.g., minutes, hours). However, when asked how they knew these units, none of them were able to justify the actual durations. Rather, other explanations for the durations were given, such as how enjoyable the experience was or what their effort to complete the activity.

Kris: Age Five

Kris began by sorting the activities into two columns, what he called the "short amount of time side" (brushing teeth and watching movie) and the "long amount of time side" (sleeping at night and eating lunch). When asked if he felt that it took the same amount of time to watch a movie as brush your teeth, he said that one was shorter, and pointed to the brushing teeth card. Similarly, when questioned about sleeping at night and eating lunch, he said sleeping at night was longer. This progression can be seen in Table 1.

Table 1. Kris's Organization Process and Reasoning

Initial Order	"Short amount of time" Brushing teeth Watching a movie		"Long amount of time" Sleeping at night Eating lunch	
Final Order	Brushing teeth	Watching a movie	Eating lunch	Sleeping at night
Reasoning	"Like five minutes."	"You can watch much." "Like 15 minutes."	"About 10 minutes."	"About 30 minutes."

Kris's initial ordering of the events was more of a classification than a seriation, where he "put everything that [was] alike together" (Piaget, 1985, p. 100) under the umbrellas, "short" or "long" amounts of time. One question that I overlooked during the interview was why he chose to group these events in such a way. Instead, I focused on his sequencing of events from the original *Experiment 3* (Tillman & Barner, 2015). Though I do feel this was a missed opportunity to better understand his overall durational reasoning.

After creating his final "timeline", Kris began by explaining his reasoning from the middle of the events, with watching a movie. He stated that it was placed in the middle because "you can watch much". Here, Kris seemed to be equating the amount of activity ("much") with duration, a common conception in early time reasoning (Piaget, 1969).

As Kris continued his explanation, he switched his reasoning from activity of an event, to standard units of time—explaining that brushing teeth was five minutes, eating lunch 10 minutes, and sleeping at night 30 minutes. I asked Kris about his use of these specific durational words, which prompted him to add that watching a movie took "like 15 minutes". From this, it seems that Kris knows that the word "minutes" can be used to explain lengths of time, an understanding highlighted by Tillman and Barner (2015). However, looking at how he now ordered the minutes of each event (5, 15, 10, 30), the value does not align with the chronological duration.

I asked Kris specifically about the chronology of the durations, comparing the order of the numbers given versus the order the events were placed. This comparison seemed to confuse Kris, as highlighted in the following excerpt.

A (Author): You said this was five minutes [taps brushing teeth card], 15 [watching movie card], 10 [eating lunch card], 30 [sleeping at night car], is that the right order?
K (Kris): I don't know.
A: Do numbers go 5, 15, 10?
K: No/
A: Do they go [flipped watching movie and eating lunch cards] 5, 10, 15?
K: No. [furrows his brow and shakes his head]
A: [Puts cards back] Okay, so you think it takes you longer to eat than watch a movie?
K: Yup!

Kris seemed confused by the rearranging of the cards, and focused more on his perceived duration of each event rather than the numbers he had assigned to the minutes of each event. This aligns with Tillman and Barner's (2015) findings that overall, the five-year-old participants performed better on organizing the duration of familiar events than on organizing timed durations (such as nine seconds or two minutes). There may also be a connection to Kris’s concept of number, although more study would be needed to make such a claim.

Sam: Age Six

Sam quickly organized the four events: first, brushing teeth on the far left (shortest duration), then eating lunch, watching a movie, and finally sleeping at night on the far right (longest duration), as shown in Table 2. She was very deliberate about pulling the cards in increasing durational order, moving from shortest to longest activity, and did not verbalize her reasoning during this process, as the other two participants did.

Table 2. Sam’s Organization Process and Reasoning

Final Order	Brushing teeth	Eating lunch	Watching a movie	Sleeping at night
Reasoning	“That’s two minutes.”	“Pretty easy and you can sometimes shove it in your mouth.”	“It’s not longer than, if you would start like in the middle of the night it wouldn’t even be in the middle of the night, it would be, like, before the middle of the night.”	“Would be like all the night, it’d be like all the day.”
	“I sometimes count it of a second and then made it up to two minutes.”			
	“30 seconds in a minute, 60 seconds in two minutes.”			

When asked to explain why she chose to order the events as she did, Sam started her explanation with watching a movie, similar to Kris. However, where Kris explained the duration of a movie through action, as “watching much”, Sam explained the duration compared to the time of day one might watch a movie (night) and the progression of time chunked as “the night”. Sam went on to compare watching a movie being the middle of the night to sleeping at night being all night and all day. This reasoning seemed to align with the use of start and end points in measurement reasoning (D. Earnest, personal conversation, May 27, 2019; Kamii & Russell, 2012; Piaget, 1969), where darkness and light serve as figural endpoints. Because in Sam’s reasoning she could watch a movie that both starts and ends in the dark, but sleeping at night starts in the dark and ends in the day (light), the duration of sleep is longer than watching a movie.

From using physical indicators of time (sun-up versus sun-down), Sam changed her durational measure to explain eating lunch through effort and activity. This use of action to explain time is a common characteristic of reasoning intuitively about time (Piaget, 1969). When asked how “shoving food in her mouth” changes the amount of time the activity takes, Sam responded by saying:

S (Sam): You would just get a handful and shove it in your mouth. [pretends to quickly shove handfuls of food in her mouth]
A (Author): How would that change how long it took you to eat your lunch?
S: Um, uh [looks up, hesitates for six seconds] I don’t know.

Sam seemed to correlate her actions to the amount of time that something can take to complete, but she could not reason how or why. Piaget (1969) explained that young children are unable to conserve velocity, believing that quicker actions equate to more time. Sam seemed to have moved past this reasoning. When she modeled eating quickly to explain how eating your lunch is a shorter activity than watching a movie, she seemed to demonstrate the inverse relationship between action and duration (i.e., moving faster results in a shorter duration).

Finally, when asked why she put brushing teeth at the far-left side of the timeline, Sam quickly responded, "cause that's two minutes". This was the first time Sam used standard units. This was also the first time during Sam's explanation that she did not hesitate in her response. I asked how she knew it took two minutes to brush her teeth, which cause her to pause repeatedly and stumble through an explanation of counting two minutes, which consisted of counting 30 seconds (which she explained was a minute) twice.

From other interviews I have conducted with children of Sam's age, "two minutes" has been repeatedly given as the duration of brushing teeth. Through many of these other interviews, children have explained that it is two minutes because: "That's what my mom told me", "That's what the dentist said to do", and "That's how long my toothbrush counts to". I cannot say if any of these accounts explain Sam's reasoning, however, with her inaccurate calculation of 30 seconds to a minute and the immediacy of her initial response, I would conjecture that she has been told by an outside source that brushing teeth takes two minutes.

Casey: Age Seven

Casey's process of organizing the events was much slower than the other two participants. She began by moving watching a movie, eating lunch, and sleeping at night to the right side (longer durations) and brushing teeth to the far left (shorter duration). She then arranged the three "longer duration" activities along the "timeline", as seen in Table 3.

Table 3. Casey's Organization Process and Reasoning

Initial Order	Brushing teeth		Watching a movie Eating lunch Sleeping at night	
Final Order	Brushing teeth	Sleeping at night	Eating lunch	Watching a movie
Reasoning	"It's just easy so you can go really quick."	"Takes a long time because I'm not that tired."	"I'm a really slow eater."	"Like an hour, that's why it's really long."
		"Not as long much time as eating."		

From the beginning, Casey seemed to focus on the effort she took to complete each activity as an explanation for the amount of time it took to complete. Casey began by stating that brushing her teeth was "easy, so you can go really quick". This reasoning seemed different than Sam's description of eating being "easy and you can sometimes shove it in your mouth", in that Casey explained that *because* it is easy you can go fast. This causal relationship seems to demonstrate a more advanced conception about the inverse relationship between velocity and duration, and was reaffirmed by Casey later in the interview, as shown below.

A (Author): If you brush your teeth fast, what does that do to the amount of time it takes you to brush your teeth?
C (Casey): Less, fast, it takes less amount of time because you go fast.
A: So faster makes less amount of time?
C: Yes.
A: If you were eating your lunch and you wanted it to take longer, what could you do?
C: Like eat really slow.

Prior to this exchange, Casey had explained that she was a slow eater when she compared sleeping at night as taking a long time but not as much time as eating. This comparison may seem illogical, since for most people sleeping at night takes longer than eating, however, I believe that Casey interpreted sleeping at night as the act of falling asleep not as the entire duration of being asleep. Thus, Casey described falling asleep as taking a "long time" because she's "not that tired".

When Casey then compared the duration of falling asleep against eating lunch, Casey seemed to, "Directly compare two objects with a measurable attribute in common" (CCSSI, 2020). In other words, Casey took the attribute time and compared the two events. And while I would argue that to Casey, time is the effort she exerts to complete an activity—not necessarily the operationalized time Piaget (1969) discussed—she still seemed to be correlating two events with this common attribute to order their lengths.

Similar to Sam, when I asked Casey about the duration of the final event, watching a movie, she flipped her reasoning from effort (easy, really slow) to standard units (an hour). Once again, Casey compared the events by stating, "[watching a movie is] like an hour and none of these stuff (points to other three cards) takes like an hour, so that's why it's really long". This is interesting, though, because unlike her previous comparison of two efforts, this is comparing effort against a standard duration. Unfortunately, I did not ask how she knew that a movie took an hour, however, this mixing of temporal conceptions may indicate some transition in reasoning, from action being a proxy for duration to time being a standardized quantity.

Discussion

From a linguistic framework, Tillman and Barner (2015) concluded that "the lexical category that children form for duration words is not a simple grouping of these words, but rather a structured, ordered scale that reflects some knowledge of the relative temporal magnitudes of the words" (p. 73). This scale, Piaget (1969) might have argued, results from the operationalization of time—from intuitive perceptions of time to the coordination of temporal and spatial relations.

Across the three interviews, Kris, Sam, and Casey demonstrated varied conceptions about time measurement as they organized the four events (watching a movie, brushing their teeth, sleeping at night, and eating lunch) along their figural timelines. But, by providing the opportunity for these children to share their reasoning, several common themes arose that echoed past mathematical research, most notably the use of action as a proxy for duration.

Piaget (1969) noted "that to primitive intuition, time is simply the 'prolongation of activity'" (p. 60) and was representative of pre-operational thinking. Kris, Sam, and Casey all explained time through activity, where "watching much" or "eating slowing" justified the placement of their duration. This attention to activity may indicate an intuitive perception of time, which, for this age range, would align with past research (Long & Kamii, 2001; Piaget, 1969; Russell, 2008).

Additionally, both Sam and Casey went further to explain how ease of activity created shorter durations (i.e., it's easy so it doesn't take much time). Perceptively, though, I believe that Sam and Casey were using the term "easy" as a substitute for "routine". Some activities such as waiting for paint to dry or being a passenger on a long road trip, might be considered "easy" as they involve little effort, however, the actual duration of these activities could be quite long. For Sam and Casey, the act of eating lunch or brushing teeth, may be so routine that it has created an instance of "temporal compression" (Flaherty, as cited by Evans, 2004, p. 736), where low levels of stimuli cause low levels of information processing, resulting it time feeling like it passes quickly. Conversely, when Casey described falling asleep at night as "[taking] a long time because I'm not that tired", it seems she was describing a "protracted duration" (Flaherty, as cited by Evans, 2004, p. 737), where the event felt long, despite the fact that she situated it on the shorter duration side of her timeline. Both temporal compression and protracted durations are based on perception, thus, indicative of intuitive reasoning of time.

Beyond the focus on activity, all three children used standard units of time to explain their sequence of events. This was not unexpected for two reasons. First, Common Core places time instruction in first grade (CCSSI, 2020), which both Sam and Casey had experienced (as a first and second grader, respectively). And second, much of what young children understand about time is the result of what their parents and other adults have told them (Earnest, 2018; Lareau, 2011; Piaget, 1969). This was most evident by Sam’s description of brushing her teeth taking two minutes with no real explanation of why. However, for all three children, the actual durations they understand for these standard units cannot be fully analyzed given the current data. Kris seemed to understand that minute was a word to describe time, but he sorted the durations as 5, 15, 10, 30 minutes and was not able to reason about the ordering of the numbers. Casey conceptualized an hour as being a long amount of time, but never explained what an hour meant beyond this. There is clearly more to learn about how children reason about these durational units as measurements of time and their everyday activities.

Tillman and Barner (2015) presented a broad quantitative analysis of how children order durational words and experiences. Many of their findings aligned with previous mathematical research on children’s conceptions of time (Earnest, 2015, 2018; Harris, 2008; Kamii & Russell, 2012; Piaget, 1969). It is encouraging to see common findings across fields of research, linguistics and mathematics.

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