Acquisition of Numerosity in One English-Spanish Bilingual Child: A Case Study

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Abstract

This paper analyzes the development of numerosity in one English-Spanish bilingual two-year old. Using three of Wynn’s 1992 number experiments that have shaped the field of children’s number-learning, I compare my subject’s results to those found in Wynn’s original paper as well as studies that have since used her same methods, especially Wagner’s 2015 work with English-Spanish bilingual children. For this study, a series of sessions was conducted over a two-month span, and then another series of sessions happened after a two-month break. Between these two series, my subject showed a jump in ability that is common amongst children during the numerosity-learning process. At each of these stages, I explored whether my subject’s experience mirrored that of a typical number-learning process. Specifically, results of previous studies predicted that my subject would progress through specific stages in his number-learning process — starting with being a one-knower, to a two-knower, to a three-knower, and eventually to a cardinal principle knower. Results of previous studies also suggested that my subject would learn his early numbers, one, two, and three, separately in each of his languages. Finally, it is expected that, once a child shows knowledge of the cardinal principle in one of his languages, he will jump to that same level of knowledge in his other language(s), “skipping” expected number-learning stages. I found that my subject generally mirrored these patterns, with some variation based on his age and specific number-learning process. Overall, this case study offers an opportunity to test whether results from previous group studies are replicated for one bilingual child as well as to gain more in-depth insights about this child’s acquisition of numerosity.
Introduction

Numerosity is the concept of mapping number words to a number system. That is, connecting the word for a given number to its representation as a set of objects. For children, there is an order in which this skill is gained. Children progress through different stages of numerical ability. At around age 2, children learn how to recite their first number words in order (Odic 2015), starting from one. Then around 2 years, 6 months, children gain the ability to understand “one” as a set of one object (Wynn 1992). They are able to represent this through a variety of different tests. A child at this stage, a “one-knower”, does not know how to represent sets larger than one. If asked for any number larger, the child will give a handful of objects. This child has an understanding of “one” and “many”, and not an understanding of any specific levels of “many”. Over the next 6 - 12 months, the child will progress through stages of being a “two-knower”, “three-knower”, and so forth. At each of these stages, any number above their knower-level results in a handful of any number of objects. After a “three-knower”, some children progress to a “four-knower” stage before entering a final “CP-knower” stage.

“CP-knowers”, or Cardinality Principle-knowers, are children that understand the cardinality principle, which is that “the last number produced when counting a set indicates the cardinality of the set” (Gelman & Gallistel, 1978; Le Corre et al., 2006; Wynn 1992 as cited in Odic et al., 2015, p. 103)—that is, CP-knowers consistently recognize that the last number counted in a set is equal to the number of items in that set. These children are able to correctly identify the number of items in sets of larger quantities. Some children skip the four-knower stage before progressing to a CP-knower level. It is important to note that while progressing through these levels, a child can have the ability to recite numbers much higher than the number of their knower-level; it is the connection to the representation of that number that children must learn. With that said, even
after progressing to the CP-knower level, it is unclear to what extent the child relates numbers to each other. A child may be at CP-knower level based on their ability to identify large sets, but may not understand that adding one to that set will result in a cardinality one larger than the set. Some researchers want to define a CP-knower as a child that has knowledge of the successor principle – understanding what n+1 represents for each number n. For my own definition of numerosity, I use my earlier example— if my subject is able to consistently recognize that the last number that he counts in a larger set of items is equal to the number of items in the set, as opposed to seeing that number as a more abstract concept, he will be labeled as a CP-knower. This paper presents a case study of the acquisition of numerosity for one bilingual child age 2:3-2:6 (years:months). The study tests whether hypotheses from previous group studies are replicated for this particular child.

**Background**

1. Numerosity in Bilingual Children

   Languages differ in the way they morphologically encode numerals. English and Spanish, the two languages that my subject speaks, both have obligatory single-plural markings (as in one cat, two cats; un gato, dos gatos). This means that the difference between one object X and more than one object X is far more clear than the difference between, say, 2 of X and 3 of X. The word-final markings on nouns that happen in both English and Spanish create a clear difference between “one” and “many”, however many there are. It is worth noting that the Spanish word “uno” (one) is more similar to Spanish indefinite articles “un/una” than the same parts of speech in English: “one”, “a/an”. This may have been a factor in my subject’s understanding of his very first number words in each language, but it proved to be less important due to his knower-level at the start of the study.
Katie Wagner’s “Why is Number Learning Hard? Evidence from Bilingual Learners” (2015) studied one hundred and forty-seven bilingual children, speakers of either English and French or English and Spanish. She found that there was not a difference in progress across number knower levels based on socio-economic status, but that knower level in the child’s primary number language affected knower level in their secondary number language in some cases. For children that were one-, two-, or three-knowers (aka subset-knowers) in their primary number language, their knower level in this language could not predict their knower level in their secondary number language. Children that were CP-knowers in their primary number language, though, were far more likely to be CP-knowers in their secondary number language than to be at a lower knower-level in that secondary language. Wagner’s results suggest that “cross-linguistic transfer may occur at the CP-knower stage, but not at the subset knower levels” (Wagner et al. 2015, 11). Additionally, “it would appear that a child who is a three-knower in one language, but only a one- or two- knower in their other might become a CP-knower in both languages at once, thereby skipping several stages in their secondary number language” (Wagner et al. 2015, 16). This process of “skipping several stages” proved to be relevant at the point that my subject showed that he was a CP-knower.

2. My Subject

My subject was 2:3 (years:months) old at the start of the study and 2:6 at the end. He speaks English and Spanish. He is primarily an English speaker, most often around English speakers talking to him or each other. His family has a high socio-economic status, which Wagner noted is not usually a large factor in number abilities (Wagner et al. 2015, 9). His father

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1 Primary Number Language being the language that the child performed best in for a series of number tests such as highest count. It should be noted this was not always the same as their Native language or the language their parents speak, if some of these kids learned math in their primary number language at school, for example.
is a native English speaker and is currently learning Spanish but does not tend to speak around the child. His mother is a native Spanish speaker (L1) who is also fluent in English (L2) and speaks English more often. Her mother, his grandmother, is also a native Spanish speaker (L1) and a fluent English speaker (L2). His parents and grandmother live together. His mother is a stay-at-home mom, so she is his primary caretaker during most work days. He hears his mother and grandmother interact with each other in Spanish, as well as speaking Spanish to him, especially to learn vocabulary words for objects (toys, food, numbers, etc). All of these caretakers speak to him in English more often than Spanish. He also has two older sisters living with him that are native English speakers and speak to him in English. He understands both languages well but tends to produce words in English more often. He will sometimes count in English when prompted to speak in Spanish. He consumes media (books, music, television) in both languages, and watches a specific television show: Number Blocks (BBC) that I believe has accelerated his number learning process, or at the very least his interest in numbers. Number Blocks teaches counting, addition, subtraction, multiplication, and division through its characters — each representing a group of blocks of a certain size. Every episode specifically emphasizes how numbers can transform by combining with each other. This program is in English.

![Image](image.png)

Fig. 1, from BBC’s *Number Blocks*

He is able to count up to at least 20 in Spanish and as high as 100 in English. For this reason, I found English to be his primary number language in addition to being his primary
language more generally. The only exception to his apparent preference for English is that he
does not usually produce “seven” in English, and will instead produce “siete” (seven) regardless
of the language of the numbers surrounding it. He produced only “siete” until around 2:4, at
which point he began switching between “siete” and “seven”, still maintaining a preference for
the Spanish word.

3. Goals of the Study

I seek to answer a few questions in relating my subject to pre-existing studies of
numerosity and language acquisition in bilingual children. For one, I want to know if his
progress mirrors results found in previous studies. I assume that his consumption of number
words and number-related material on a daily basis will lead to him progressing through stages
faster than expected. I want to know if, besides the expected age timeline of progression through
number stages, he is following similar patterns. I will focus on the progression from being a
subset knower to a CP-knower by examining the following predictions:

I. From previous research, I expect my subject to progress to being a CP-knower after
gaining subset knowledge up to a three- or four-knower.

II. I expect my subject to progress through subset-knower stages at different times in each
of his two languages. Research has shown that, especially for early numbers one, two, and three,
number learning is disjoint across each language of a multilingual child.

III. I expect that, if he has become a CP-knower in one of his languages, he will also
become a CP-knower in his second language, regardless of his subset-knower level before
becoming a CP-knower in the first language.
Methodology

Each of the following tasks was conducted on a Zoom call with the child and his Spanish-English bilingual mother. For some tasks, his mother was more active, and for others, I as the researcher conducted the experiment with my subject. For the child’s protection, these sessions were held in a password-protected Zoom call. The videos were viewed only by the researcher. Data was then recorded in an anonymous spreadsheet. Videos were deleted at the termination of the project, and the spreadsheet is the only material kept after the completion of the project. The following tasks were taken directly from Wynn’s “Children’s Acquisition of Number Words and the Counting System” (1992), which is one of the most widely-referenced papers in this subject. It provides a baseline of expected performance based on a child’s age. I conducted nine sessions with my subject, six sessions a week apart spanning from October to November 2020, as well as three final sessions at the end of December 2020 and the first week of January 2021. My subject was 2:3 (years:months) at the start of my research, and 2:6 at the end of the study. Each session lasted from ten to fifty minutes, depending on my subject’s attention span. While I had planned to dedicate each session to a specific task, this did not happen due to my subject’s preference for the “How Many” task. My subject was significantly younger than most past participants in similar studies, and I tailored the sessions to fit the activities he was willing to perform at each point in time as a young two-year old. The tasks were as follows:

1. How-Many Task

This task asks a child to first count the number of objects he is shown, and then asks him: “How many are there?” or “Cuántos hay?” again being careful to avoid naming the object with/without a plural marker whenever possible. This task can be a determiner of whether a child associates
the last number in his counting with the overall value of items in a set, because studies have shown that CP-knowers are far more likely to be able to correctly name the last number as the value of the set as a whole (Wynn 1992, 243). The same study, however, warned against using this method exclusively, or as primary evidence, because some children will learn that they are rewarded for repeating the last number of a set before showing other understanding of that last number being the value of the entire set (Wynn 1992, 243). Some example materials for this task are shown below. The child is shown these materials one at a time.

![Example Materials](image)

**Fig. 2, Example Materials for How Many Task**

2. **Give-a-Number Task**

This task asks the child to produce a given number of objects when prompted. The child’s parent asks him: “Can I have X?” or “Puedo tener X?” Where X is a number of a specific object. The parent is careful not to specify in the question “X objects” so as not to signify a single/plural marking to the child. The child first does 1, then 2, and then X+1 from there. If the child does not perform the X+1 task correctly, they will go back to X. The tasks are performed with the below plastic colored bear figures. When conducting this experiment, only one color of bear was used, so as not to suggest an association of a color with a number. When playing on his own, the child would count the bears in a certain color order. I did not want to support this association for this task, so I used materials that were all the same color.
3. Point-to-X Task

The Point-to-X Task was performed based on the child’s performance in the first two tasks. In this task, the child was asked to compare two sets of objects, and name which set represents a numerosity requested by the researcher. This task requires a higher level of ability, and was only performed because the child proved to have above a two-knower level ability in each of his languages after the completion of the first sessions of each of the above tasks. This task utilized materials such as the cards provided below. My materials featured stars, like the image on the right.

Fig. 3, Example Materials for Give-a-Number Task

Fig. 4, Example Materials for Point-to-X Task, from Wynn 1992
Results

In my nine sessions with my subject, each one was a mixture of tasks in English and Spanish. While I tried to start with a certain task and language and stay focused on that task/language, I had to work with what my subject was comfortable with. Because my subject is so young on the spectrum of studied ages, his preferences influenced the direction of each session. Some sessions he was more cooperative than others, and sometimes he only wanted to do one task and not another. Because of this typical two-year-old behavior, my data skewed heavily towards his own preference for the how-many task, as well as his preference for responding in English. This skew means that I have the most data for the how-many task, but, as stated earlier, it cannot be used as exclusive evidence of knower-level, because children will learn that they are rewarded for associating the last number counted with the correct value of the whole set before grasping understanding of their full connection. It is possible that this is true with my subject; he was able to perform well on relatively high numbers in both English and Spanish on the how-many task, and less so on the give-a-number task.

I have organized his results by session below. The sections marked English data represent times where my subject was prompted in English (and responded in English). For times where he was prompted in Spanish but responded in English, I made note. This happened quite often in attempts to collect Spanish data. There were no situations where he was prompted in English and responded in Spanish. Otherwise, Spanish data references only times where he responded in Spanish (and this, again, is only the times where he was prompted in Spanish). For each table, the x-axis shows the numbers that my subject was asked to respond to. In blue, his “passes” are shown. This means, for the give-a-number test, him giving the requested number of objects to a certain person or toy as directed. For each prompt, he is given a chance to correct any wrong
answers with follow-up questions such as “is that X?” “can you count and make sure?” as was done in Wynn’s original study (Wynn 1992, 229). If he corrects any incorrect response in two chances, that is counted as a correct response. Otherwise, it will be labeled as a “failed” response, seen in orange. In cases where my subject did not settle on the correct answer but did not firmly decide on an incorrect answer, his response was labeled as “inconclusive”, shown in grey. For the how-many task, he was similarly given a chance to get the right answer if he did not get it immediately. Results show his eventual outcomes given two tries, not the results of a first try.

The first session, on October 8, 2020, was entirely in English and consisted of the give-a-number task. Results are shown below.

In this task, I was able to test mostly the number one, in order to establish a baseline. As my subject gained a better understanding of what the test was, he was able to show his understanding of two and three. Here, the y-axis represents that I prompted my subject to hand me one bear three times, asked him about two bears two times, of which he passed one and failed one, and asked him about three bears one time. He had mixed results for two on this day, but I chose to move on to three because he seemed to be getting used to what the task was asking of him. Once he had a better understanding of the task, he performed better. While this session was focused on the give-a-number task, questions like “how many bears are here?” were used throughout and
often held my subject’s attention better than asking him to move the bears himself. While this is notably *not* the same thing as the how-many task itself, it is worth noting his responses of these questions. During this session, he was asked “how many” referring to a pile of five bears, and responded correctly. He counted up to five and confirmed seeing five objects. This response mirrors what we see in future responses to the how-many test as it is conducted more formally.

For the next session, the following day, my intention was to focus on my subject’s Spanish skills on the same task, give-a-number. Unfortunately, his attention span on this day was not particularly high. I was not able to collect as much data. These are results for questions he answered completely, in Spanish, after being prompted in Spanish. He showed that he was answering in Spanish by counting to the requested number in Spanish.

![Spanish Give-a-Number Session 2](image)

This table shows that, while there were not as many responses, he seems to perform somewhat similarly as in English the day before. I was only able to collect data for “dos” and “tres” this day. Retrospectively, I wish that I had focused on “uno” like I had in the first English session. During this session, my subject also modified the test in a way that he preferred, by adding one-by-one to a pre-existing group. After correctly bringing a group of three to his mother, he added one and named it as “cuatro”. Then, again, added one and named that as “cinco”. After cinco, he added one more, and said “that’s ocho”. This process only shows his apparent knowledge of number order up to “cinco” in Spanish, and does not necessarily show that he
understands that the group of objects represented that number. I have no explanation for his jump from “cinco” to “ocho” when he seemed to understand a group building by one as it stepped between “tres” and “cinco”. It is also interesting that he used English in his surrounding words here, saying “that’s ocho” instead of, for example, “eso es ocho”. It shows his fluency in and preference for English over Spanish, even as he is able to use Spanish counting words.

The next session, October 15, shifted focus to the how-many task. At the start of the session, I conducted the task in English.

For this task, I was only able to ask each question one time, with the exception of a picture of three objects that I asked about twice. Even though these questions weren’t answered with frequency in this session, my subject’s responses show that he has some understanding of these groupings. While I showed him the groups out of their regular order, he did trip up at some points where he wanted the next group to be the following number in the order he knew. Once getting past that point, he understood the task, though he still would have wanted the groups to be in the number order he knew if he had a choice. His responses for one of his threes and for his four both took two tries and were correct only on the second attempt. I made a note during this session that his response to the six item picture was especially fast, and it seemed like he almost guessed how many objects there were and then counted up to his idea of how many there were. While this may all be speculation, it is to point out that he may have been doing what some
young kids do when presented with this task: learn what is expected of them (repeating the last number after counting up to that number), and focus more on getting that one last number instead of understanding that that number represents the whole group.

Later during this same session, I transitioned to a Spanish version of the same task. In retrospect, I wish I had done the Spanish first, because my subject may have been losing interest after answering so many English questions. Regardless of the reasoning, he had very few responses that were actually in Spanish when prompted in Spanish.

The above table shows his Spanish responses to Spanish prompts. He answered a question about each group once, getting the question right for the first three numbers and wrong for the fourth. For one of these values, though, there is more to the story. When my subject was asked for “cuatro”, he first counted, in English, up to four, correctly. This is separately from his English results for “four” above. So, again, he proved his English knowledge of four. However, when asked to repeat the task “en español?” he counted “uno dos tres” and would not correct or change that answer. This is interesting because it suggests that he wasn’t directly translating “cuatro” and “four”.

For the next session, on October 22, my intention was to repeat the how-many task in Spanish to fill in gaps in what I knew about my subject’s ability level. This did not go as planned. I was able to get one answer to one question in Spanish — when prompted to name a
group as cuatro, the exact question he had gotten wrong the previous week — he correctly counted, in Spanish, to cuatro. Other than this one instance, he was not engaging in this task in Spanish. He answered one other how-many question asking for five by responding, correctly, in English, even though he was prompted in Spanish. After attempting to engage my subject with this task, I decided to switch gears and see if he would engage with the give-a-number task in Spanish, knowing I also had gaps in Spanish for this task. This fared better. His results for the give-a-number test in Spanish are as follows:

![Image](image.png)

In this part of the session, I prompted my subject for 2, 3, and 5 objects. In addition to these results, he answered one give-a-number question asking for “dos” objects by counting in English to two, correctly answering the question. These responses were sparse because, again, my subject’s attention span on this day was short, and these answers were few and far between. Notable, however, is his response to a request for “cinco” objects. Here, he performed the way literature predicts children perform on groups past their knower level: instead of trying to count up to “cinco” bears, he grabbed a big pile of bears and said “that’s cinco” (note, again, the mixing of languages here). This signifies that the group is beyond his Spanish knower-level. Because of this, I can rule out any possibility of him being a CP-knower in Spanish at the point of this session, though his strong preference for English even when prompted in Spanish already suggested this to me. A response to a request for “cuatro” objects in either task would differentiate between him being a three-knower and four-knower in Spanish.
During the next session, October 30, I intended to conduct the point-to-X task. However, the way that I had set up this task did not signify to my subject the clear difference between two groups. Instead of having his mother show up the two groups on two separate cards in person with him, I had a version of that set up on my screen, shared via our zoom call. This clearly was not a big enough difference, and instead of seeing two groups (of one object and two objects, for example), he saw a group of three. Because of this, I decided to follow his lead, and get more how-many results. Again, I wish I had clearly asked for Spanish at this point, but perhaps with the groups being larger it would not have helped, given that he was clearly a subset-knower in Spanish after the last session. Due to the nature of this setup, I had pairs of objects that were one object apart (two and three, four and five, etc). So, for this task, the numbers are higher, and are all odd numbers, except for one grouping of four and two (labeled as six). These results are labeled as a how-many task, because my subject didn’t see any difference in groups. Here are the English how-many results from this session:

Notable here is that for each of the “seven” questions, my subject needed two chances to get the correct answer. He seemed unsure of himself, but did eventually land on seven. For “nine”, he was never able to land on the right answer. Considering the confusing nature of this adapted task, he performed well. As I had said with his last how-many task, he seems to decide quickly how many of some object there are, before he could have possibly counted them. Then, he counts in order to reach the number in his head, which often is the correct one. For this reason I am very
cautious to label him as a CP-knower though he has the ability to do well with higher numbers in this task. Maybe these results suggest a transition between a high subset-knower level and becoming a CP-knower. Later in the session, once my subject was no longer excited about the give-a-number task, I asked him a couple of give-a-number questions. I asked three questions, and only one had a Spanish response: a request for “tres”, that he did correctly. His “dos” request was responded to in English, and for a request for “cuatro”, he counted in English “one, two, three” and then at the last number, said “cuatro”. This to me was important, because he recognized the importance of the last number counted as well as, seemingly, some understanding of the translation between his languages. Still, I hold to him being a subset-knower, but this data leans towards a four-knower and not a three-knower.

For his last session of this first series, on November 5, I again attempted a mixture of tasks, starting in Spanish with a version of the how-many task: here, instead of pictures, he counted how many there were from a group of blocks in front of him.

![Spanish How-Many Session 6](image)

Here, he confidently named groups of “cuatro” and “cinco” correctly. For “seis”, he added one to “cinco” and named it as “seis”. While this is a good showing of his knowledge of the number line, it does not answer the task in the same way. He then attempts to answer one similar question in English, a request to name a group of seven, but cannot do so successfully, again affirming his place as a subset-knower. Then, in the same session, we did some give-a-number questions, in both languages. In English, he answered requests for two and three correctly. In
Spanish, he responded in English, and answered four correctly. Each of these requests happened one time.

The results of this first series of six sessions that I have just presented indicate that my subject was a subset-knower in each of his languages at the time the series concluded. While he had times where he was able to correctly name sets of larger sizes, his inconsistency shows that he is still a subset-knower, potentially with a transition to being a CP-knower starting to happen. At this stage, he seemed to be a higher subset knower in English than in Spanish. He showed that he could at least understand 4 in Spanish, and 5 in English. It is unusual for a child to be a five-knower as a subset level before becoming a CP-knower, but it is also unusual for a child as young as my subject to be a high subset-knower more generally.

After a break of around two months, in the last days of December 2020 and first days of 2021, I conducted three final sessions in order to place his potentially changed knower-levels in each of his languages. In these sessions, I conducted point-to-x tasks in both languages as well as updated give-a-number tasks. First are his English point-to-X results. For this table, I have set up two categories: one in the case that I requested the larger of two values, and one the lesser. For each of these categories, a wide range of comparisons were tested, going from 2 vs 3 (choose 3) to 7 vs 8 (choose 7). He performed extremely well on these tests and any mistakes he made he was able to fix. Again, this represents that he was asked seven comparisons where he should choose the bigger number, and five where he was told to choose the smaller number. He responded correctly to every one of these questions. Besides comparisons one value apart, each category also includes one question where my subject was asked to choose between 1 and some larger number X (once asked to choose X and once asked to choose 1), a question that is often used as a diagnostic of an understanding of plurality in general. Below are his results.
With these English results, he shows clear progress, especially because these results include comparisons between larger numbers, up to 8. During this same session, I also conducted a Spanish point-to-X task. Similarly, I asked my subject to choose between numbers one value apart, ranging from 1 to 8. Included in these results was a choice between 1 and 5 (both choose 1 and choose 5), to again test for knowledge of plurality. These results are shown below.

Again, my subject was able to answer each of these questions correctly. In cases where he initially wasn’t sure of his choice, he counted and came up with the right answer. This session suggested to me that during the time off from our sessions together, his number knowledge had grown tremendously in both of his languages. In order to confirm this growth, I conducted give-a-number tasks in each language in his final two sessions. First, I conducted the task in English.

On January 1, 2021, I held a short session with my subject to test his English give-a-number abilities after our two-month-long break. I tested larger numbers in order to figure
out if he had become a CP-knower in this language, his primary number language. I was able to ask him four questions. The results are below:

He was able to correctly create groups of 4, 5, 6, and 9. This ability leads me to believe that my subject is now a CP-knower in English. According to Wagner, this new ability level in English may mean that a similar ability level has been reached in Spanish (Wagner et al. 2015, 16). I conducted a final session on January 3, 2021 to test my subject’s Spanish ability in the Give-a-Number task. The results are shown below:

These results show that my subject was able to correctly respond to numbers in Spanish up to 8. This is far beyond his previous ability. It is important to note that these results were not quite as seamless; it took a few tries for my subject to get to “ocho”, at first he counted up to “seis” and then added two on his own to reach “ocho”. He also correctly gave a stuffed animal 6 bears one time beyond what is shown, but he counted in English. So, still, he has a preference for English, but has clearly grown in his ability in both languages. From these results, I am able to conclude
that my subject followed predicted findings: once the child reaches a CP-knower level in one language, he is able to jump to reach CP-level understanding in his second language as well. These results show that he has grown to be a CP-knower in Spanish as well as in English.

Below, I will summarize the entirety of my results, separated into series one and two. For series two results, these are the same as shown above. For series one, these are combined results. I will put them side to side here for a final comparison. First, the English Give-a-Number task:

Here you can see my subject’s growth in this task between series one and series two. I wish that I had gotten more data for larger numbers in series one to confidently confirm my subject’s inability to perform past around five. His English responses to Spanish tasks for these higher numbers aided in my labeling of him as a five-knower instead of a CP-knower at this point in time, but those results were not added to this combined table because of the difference in questions asked. Next, my subject’s Spanish results for the same test:
Here, you can more definitely see the difference in ability from series one to series two. At the point of the first series, my subject was unable to perform this task for five objects. For the second series, my subject performed correctly for each question that was asked of him. His Spanish knower-level grew significantly. Next, we will review English and Spanish How-Many tasks as totals from series one. This task was not conducted in series two.

This task, in English, seems to show a very high knower-level, even at the point of series one. The caveat here is the ability of a child to trick the test — figuring out that repeating the final number will get the correct answer of the task before gaining true understanding that this final number represents the whole group. For this reason, I rely more on the Give-a-Number results than these results for determining my subject’s knower-level for series one. In Spanish, my subject never grasped this task to the extent that he did in English. He showed his understanding up to at least “tres”, but past that, his performance was hit-or-miss. This is indicative of his knower-level at the time, determined to be around a four-knower. Finally, we will look at English and Spanish results of the Point-to-X task, conducted only in series two.
His entirely correct responses here show, again, a clear and undeniable high knower-level. He was asked to compare numbers as large as eight or “ocho” here, and performed flawlessly. This test along with the series two give-a-number results confirmed that my subject had become a CP-knower in each of his languages between series one and two of testing.

**Discussion**

In my goals section above, I laid out three predictions for my study. I will now compare these expectations to my own results. I will reiterate these predictions as I respond:

I. From previous research, I expect my subject to progress to being a CP-knower after gaining subset knowledge up to a three- or four-knower.

   A. I determined my subject, age 2:3 at the start of my study, to be a five-knower in English and a three- or four-knower in Spanish during our first series of sessions together. This means that I never examined any lower-subset knowledge from him. However, once I conducted my second series of tests, age 2:6 for my subject, he had progressed in each of his languages to the CP-knower stage. So I did see the expected progression from subset-knower to CP-knower. This differed from past research in how young my subject was when this change happened. According to past studies, the mean age of a child in the CP-knower level was 3:6 (Wynn 1992, 230). This means my subject was a year younger than the expected age of a CP-knower. The speed of my subject’s transition between knower levels may also be worth noting. We cannot say how long he was at the first series knower-level, but Wynn expects the transition from one knower-level to the next to take around six months, or sometimes more. It is possible my subject had been at his same high-subset knower-level for three months before our study began, but
it may be that he progressed through these stages especially fast. Additionally, my subject was a five-knower in English at the time of the first series of sessions. This is a knower-level that hasn’t consistently existed in past studies. Usually, a child will progress through knower-levels 1, 2, 3, and occasionally 4 before crossing over into being a CP-knower. Perhaps my subject being so young and being so excited about numbers as a concept changed his progression pattern. He created a space between a subset-knower and a CP-knower to accommodate for his quickly growing knowledge of number words and concepts. It seems as though he was trying to push into the CP-knower realm before he was ready, and therefore existed in a halfway-space as a five-knower at the time of the first series of sessions. He was a three- or four-knower in Spanish at the time, which is a more predictable subset-knower level. It is, again, far higher of a level than what is expected for his age group. It is possible that the sessions themselves contributed to my subject’s knower level, and that specific exposure to number concepts led him to learn the concepts faster.

II. I expect my subject to progress through subset-knower stages at different times in each of his two languages. Research has shown that, especially for early numbers one, two, and three, number learning is disjoint across each language of a multilingual child.

A. This proved to be true with my subject. At the time of the first series of sessions, my subject was at a higher knower-level in English, his primary number language, than Spanish, his secondary number language. He was, at that point, a five-knower in English and a three- or four-knower in Spanish. Because my subject was at a high subset-knower level in each of his languages at the start of
my study, I was not able to examine the process of his very early number learning, as he gained understanding of 1, 2, and 3. Additionally, he confirmed his preference for English in the way that he often responded in English even when prompted in Spanish. He was not as comfortable speaking or thinking about numbers in his secondary (number) language. It is also worth noting that my subject would sometimes use English words when responding in Spanish number words, saying things such as “that’s ocho”. This brings up a question of how much processing my subject was doing in his secondary number language (Spanish) even when he responded with Spanish numbers.

III. I expect that, if he has become a CP-knower in one of his languages, he will also become a CP-knower in his second language, regardless of his subset-knower level before becoming a CP-knower in the first language.

A. This proved to be mostly true with my subject. At the point of the first series of sessions, my subject was at a higher knower-level in English than in Spanish. Then, at the point of the second series, he was a CP-knower in both of his languages. He proved to have skipped a level that existed in his English learning progression, this five-knower level that he had in English during the first series. The complication to this, though, is the non-existence of this level in past research. If the normal progression of knower-levels is from three- or four-knower to a CP-knower, that progression in Spanish does not necessarily mean that he “skipped a level” between the first series of sessions and the second. My reasoning for saying that my subject skipped a level is that, for one, compared to his Spanish knower level in the first series, he had undoubtedly gained a lot of
knowledge by the point of the second series of tests. My second bit of reasoning for this is that my subject created a category between the four-knower level and the CP-knower level for himself in his English number learning. Does this mean that this same pattern would have been reflected in his Spanish number learning if he didn’t “skip” to being a CP-knower? It is hard to know for sure. I think that, because of such a clear jump in his ability from series one to series two only three months later, my subject’s data supports this concept of a CP-knower level in one language leading to a jump to CP-knower level in the other language.

Conclusion

My subject’s data was consistent with past studies for the most part, with some caveats more specific to him as a subject. My subject posed some limitations in my research: he was far younger than the average age of a child in past research, and because of that, he had a far shorter attention span. I wish that I was able to work with my subject more consistently or for a longer period of time. His attention span made it so that each session consisted of whichever tasks he was willing and excited to participate in. This limited the amount of data I was able to collect in general, as well as, especially, how much data I could collect for the give-a-number task and for any Spanish test, both of which he was less excited about. I also had a biased view of what tasks were over- and under-represented at the point of conducting each session. In reviewing each session, I realized that I had mistakenly thought that I needed more of a certain task, when actually I needed another. This could have been solved by a shorter period of time between each session and my transcription of each session. For future studies, I would be sure to review any session immediately after conducting it to confirm what information was collected and what may have been missing.
In conclusion, I was able to track the growth of numerosity in one English-Spanish bilingual two-year-old, and watched that two-year-old grow from a subset-knower to a CP-knower in both of his languages. This study also raised many further questions: what happens next, once a child is a CP-knower? When do children start really understanding basic arithmetic? Does this happen in phases similar to the subset-knower to CP-knower progression? My subject shows interest in adding one to a number to get the next number. How does this process blossom? What does that look like for a bilingual child compared to a monolingual one? I would also be curious about the role of zero in a child’s understanding of numbers. Is zero considered a number that must be learned alongside one to x? Is it in a category of its own? How do children come to understand the value of zero? There are so many potential questions as a child grows in their understanding and interest of numbers.

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