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The present study examined whether region of living (i.e., Appalachian rural or Triad urban), age, and cognitive abilities (i.e., cognitive flexibility and serial order) predict children's understanding of ecological food chains. Ecological food chains describe the dietary interactions of organisms and are foundational environmental ideas children are taught about the natural world. It was hypothesized that rural children would have better performance on the ecological food chain tasks due to increased exposure to nature. It was also hypothesized that urban children would need increased cognitive flexibility and serial order to perform well on the ecological food chain task. Ninety-two 4- to 6-year-old children participated in this study, and completed the ecological food chain tasks, a cognitive flexibility measure, and a serial order task. Participants were recruited from both urban (n = 45) and rural (n = 47) areas in North Carolina. Older children were better than younger children at assembling food chains, but there was no difference between region of living. It was found that older children were better than younger children at justifying food chains and rural children were better than urban children at justifying food chains. Cognitive flexibility and serial order were not predictive of ecological food chain task performance. These findings suggest that as children age they are better at recreating and explaining food chains and rural children have a cultural and geographical environmental awareness that assists them in having an increased understanding of ecological food chains.

RURAL APPALACHIAN AND URBAN TRIAD CHILDREN'S UNDERSTANDING AND JUSTIFICATION OF ECOLOGICAL FOOD CHAINS

by

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As I cross the finish line, the most valuable lesson I learned at UNCG is described by Denzel Washington in two words: fall forward.

TABLE OF CONTENTS

LIST OF TABLES ... vi

LIST OF FIGURES ... vii

CHAPTER I: INTRODUCTION ... 1

Limits on Children’s Ecological Reasoning Capabilities ... 2

Children’s Understanding of Ecological Food Chains ... 5

Cognitive Skills Needed to Reason about Food Chains ... 6

Cognitive Flexibility ... 6

Memory for Serial Order ... 8

Cognitive Skills in Food Chains ... 9

Increased Exposure to Nature Among Rural Children ... 10

The Present Study ... 11

CHAPTER II: METHOD ... 15

Participants ... 15

Materials ... 19

Ecological Food Chain Task ... 19

DCCS Task (Cognitive Flexibility) ... 19

Serial Order Task ... 19

Procedure ... 19

Measures ... 20

Defining Children’s Exposure to Nature ... 20

Ecological Food Chain Task (adapted elements from Allen, 2017; Gallegos et al., 1994; Leach et al., 1996a, 1996b) ... 20

Familiarization Trial ... 20

Practice Trial ... 21

Training Trial ... 22

Test Trials ... 24

Coding Scheme and Scoring ... 24

Virtual Dimensional Change Card Sort Task (Doebel, 2020; Stucke et al., 2022) ... 25

Pre-Switch Test Trials……………………………………………………………………26
Post-Switch Test Trials…………………………………………………………………..27
Serial Order Task (adapted from Guyla & Colombo, 2004)………………………………..27
Practice Trial……………………………………………………………………………..27
Training Trials……………………………………………………………………………...28
Test Trials…………………………………………………………………………………..29

CHAPTER III: RESULTS 30
Exposure to Nature Questionnaire..30
Ecological Food Chain Accuracy (FC Accuracy) 31
Ecological Food Chain Justification (FC Justification)..32
Ecological Food Chain Cognitive Flexibility Justification (FC Cog Flex) 34
Cognitive Flexibility (DCCS) 35
Serial Order 37
Regression Models 39

CHAPTER IV: DISCUSSION 46
Limitations and Future Directions...53
Conclusion and Implications...58

REFERENCES 60

APPENDIX A: STIMULI FOR ECOLOGICAL FOOD CHAIN TASK...................................70

APPENDIX B: THE DIMENSIONAL CHANGE CARD SORT STIMULI..............................75

APPENDIX C: STIMULI FOR SERIAL ORDER TASK………………………………………76

APPENDIX D: REGION OF LIVING BY ZIP CODES……………………………………..79

LIST OF TABLES

Table 1. Frequency of Children's Biological Sex by Region of Living and Age 16

Table 2. Demographic Data Based on Region of Living 18

Table 3. Frequency of Parent Nature Exposure Response Based on Region of Living 31

Table 4. Frequency of FC Accuracy Performance Based on Region of Living and Age 32

Table 5. Frequency of DCCS Performance Categories Based on Region of Living and Age......36

Table 6. Pearson Correlations between Measure Variables, Region of Living, Age, and Biological Sex..38

Table 7. Multiple Linear Regression Model: Full Sample on FC Accuracy................................40

Table 8. Multiple Linear Regression Model: Nature Questionnaire Subsample on FC Accuracy 41

Table 9. Multiple Linear Regression Model: Full Sample on FC Justification............................42

Table 10. Multiple Linear Regression Model: Nature Questionnaire Subsample on FC Justification..43

Table 11. Multiple Linear Regression Model: Subsample on FC Accuracy (No Nature Questions)..44

Table 12. Multiple Linear Regression Model: Subsample on FC Justification (No Nature Questions)..45

Table A13. Correct Organism Order for Ecological Food Chains 74

Table B14. Region of Living Defined by ZIP Code 79

LIST OF FIGURES

Figure 1. FC Justification Based on Region of Living and Age in Years....................................34

Figure 2. FC Cog Flex Based on Region of Living and Age in Years 35

Figure 3. Serial Order Total Scores Based on Region of Living and Age in Years 37

Figure A4. Stimuli for Familiarization Trial 70

Figure A5. Stimuli for Training Trial 70

Figure A6. Stimuli for Food Chain A 71

Figure A7. Stimuli for Food Chain B...72

Figure A8. Stimuli for Food Chain C...73

Figure B9. Stimuli for DCCS 75

Figure C10. Mr. Krabs 76

Figure C11. Patrick 76

Figure C12. Sandy...77

Figure C13. Squidward 77

Figure C14. Plankton 78

Figure C15. SpongeBob 78

CHAPTER I: INTRODUCTION

The human experience of nature (i.e., non-man-made products of the earth including animals, plants, and raw untouched landscapes; Kaplan & Kaplan, 1989), has changed throughout time. Originally as a hunter-gatherer society, humans had to depend on nature for survival; nature embodied everyday life. However, individuals in modern urban society do not regularly take the time to directly engage with the natural world despite still being surrounded by nature in their daily lives (Eder, 1996). In 2008, the world's population of urban residents outnumbered the rural population (Satterthwaite et al., 2010), and it was projected that by 2025 the world's rural population would stay the same while the urban population would increase by a billion people (Satterthwaite et al., 2010). Migrational changes are also leading to fewer careers concentrated around nature (Eder, 1996; Satterthwaite et al., 2010). It is even more likely for an American to be incarcerated than to have a career as a farmer (Thompson, 2019). Although it is understood that experiences with nature play an important role in the development of children's biological knowledge (Cheng & Monroe, 2012; Kaplan & Kaplan, 1989), there is little empirical research that examines how differences in children's immediate surroundings within their region of living impact the development of biological understanding and the implications rapid urbanization could have on such understanding.

Urban life's industrialization catalyzes pollutants and destroys green spaces, wildlife, ecosystems, and biodiversity (Shen et al., 2008). As a result, urbanization is igniting the depletion of hands-on learning opportunities and experiences of nature. Therefore, children in urban settings may have different experiences with nature than those in rural settings, both in quantity and quality, because of the type of areas surrounding their homes and their lifestyles within these areas (Eder, 1996; Khan, 1999). These different geographical locations and population densities could allow children to have different exposure to what nature is, leading to greater variability in how to reason about the natural world. Children's dissimilar experiences in nature may lead to culturally specific conceptualizations of nature that differ based on region of living. That is rural children, compared to urban children, may hold a deeper understanding of ecological concepts due to daily nature immersion. One potential consequence of rural children's daily exposure to nature and animals could be increased ecological reasoning abilities, understanding, and inferences made about living things' relations and interactions, compared to their urban peers (Coley, 2012; Ross et al., 2003).

Limits on Children's General Ecological Reasoning Capabilities

The tendency to create naïve biology frameworks to organize information about the natural world is a universal basic cognitive process (Inagaki & Hatano, 2006). Young children's understanding of animals is reflected by their reasoning about the different category memberships each animal holds (e.g., mammals, bears, omnivores; Atran, 1990; Carey, 2000). Young children have limits in their categorization abilities about the biological world. One source of these errors stems from children's inability to represent an animal as holding multiple category memberships (Atran, 1990; Carey, 2000). Over time, children understand an individual animal can hold multiple memberships. For example, a black bear is an omnivore, so it is both an herbivore and a scavenger. The black bear will eat berries, but it will also consume the flesh of decaying animals. However, when children only grasp some of an animal's memberships (e.g., The black bear eats berries!), children lack a full understanding of the role the animal plays in the ecosystem (e.g., The black bear eats berries and consumes other animals often once they are dead). For children to understand any given animal's multiple-category memberships and how they interact with the wider ecosystem, children must first have the ability to engage in inductive reasoning to infer such memberships based on the animal's characteristics.

Another source of categorization errors comes from young children's tendencies to make generalized assumptions about novel animals that may be inaccurate. Children do this by generalizing one animal's biological features to other animals when making category membership distinctions (Gutheil et al., 1998). Typically, this information about an animal's biological features is generalized across animals with the same order ranking (e.g., predator, animals that eat other animals and prey, animals that are eaten by other animals; Inagaki & Hatano, 2006). For example, children find it easier to first identify the apex predators like sharks from their common features (e.g., larger size, sharper teeth, and/or claws) than to identify the lower-order organisms like squids (Tsoi, 2011). Children create a naïve biology framework by categorizing all larger-sized fish with sharp teeth as apex predators that eat smaller sea organisms. Naïve biology theories are then created by assimilating novel information into the existing frameworks when learning about related biological phenomena and holding the assumptions they make as true until given evidence that disproves their idea (Atran, 1990). For example, when considering the large size and teeth of a manatee, children utilizing a naïve biology framework would first categorize the manatee as an apex predator; however, it is an herbivore and therefore at a lower trophic level of the food chain.

Naïve biology frameworks are based on presumptions drawn from life experiences (Atran, 1990), but as children age their inductive reasoning abilities allow them to categorize organisms in ways based less on assumptions. When biological concepts are unfamiliar to children, children relate the animal processes to those of humans to have a representation of something more familiar (Inagaki & Hatano, 2006). Inductive reasoning assists children in recognizing more than just the similarities of organisms' characteristics, but also their differences (Atran, 1990). The type of experiences that lead to the formation of biological frameworks are directly impacted by children's cultural and social environments (e.g., values related to the natural world; Atran, 1990; Atran et al., 2005; Eder, 1996; Martell, 1994; Medin & Atran, 1999) and influence how children engage in inductive reasoning when making claims about new organism (Atran, 1990; Coley, 2012; Medin & Atran, 1999). Thus, region of living can have a marked impact on both children's biological frameworks and their inductive reasoning skills about specific ecological processes.

Coley (2012) examined the differences between children in rural, suburban, and urban communities in their abilities to infer pseudo-biological facts about animals of similar taxonomic relation through inductive reasoning. Older children and children living in rural areas reported being more likely to spend time outdoors and participate in activities involving and learning about nature. Following the design of the Triad Task (Gelman & Markman, 1986), children were taught a new property about a category of animals and asked if similar and different animals shared this property, thus requiring children to utilize inductive reasoning skills. Eight-year-olds were more likely to make ecological inferences about the insides of animals compared to younger children. When comparing the geographic location of the children and their performance on the task, rural children had more consistent inference responses and displayed fewer inductive reasoning errors than suburban and urban children. The conclusion was drawn that spending more time in nature and living in a rural area led to more accurate ecological reasoning. Beyond categorizing organisms and making ecological inferences, an explanation for the flow of energy through consumption and interactions of organisms within an ecosystem can be provided through ecological food chains (e.g., grass-grasshopper-frog-snake-eagle). The interdependency of organisms on other species and the environment in which organisms live is also described in food chains (Allen, 2017; Jordan et al., 2009; Leach et al., 1996a, 1996b).

Children’s Understanding of Ecological Food Chains

Essential ecological knowledge is developed by learning through food chains that each organism has an important niche within the entire ecosystem. Food chains also give a clear explanation that with the absence of any organism, the ecosystem will no longer function the same (Allen, 2017; Gallegos et al., 1994). This study specifically examined children’s ecological knowledge about food chains and how understanding ecological food chains could differ based on children’s region of living.

Most of the research on children’s understanding of food chains comes from the discipline of environmental education and utilizes methods of descriptive research. Children as young as 3 years of age can accurately memorize the basic food chain pattern but are unable to comprehend the significance of an organism at each level (Gallegos et al., 1994; Jordan et al., 2009; Strommen, 1995). For example, 3-year-old children can memorize the food chain grass-grasshopper-frog-snake-eagle, but not recognize the grass is being eaten by the grasshopper and the frog is eating the grasshopper. Three-year-old children tend to explain the food chain order by size (i.e., the frog is bigger than the grasshopper and the snake is bigger than the frog; Gallegos et al., 1994; Jordan et al., 2009; Strommen, 1995). Until 6 years of age, most children lack the understanding to explain the interdependency organisms have with the entire food chain beyond the simple relationship of organisms eating one another. Children younger than 6 years of age also do not view the single organism depicted in the food chain as representing the entire population (Shepardson, 2002). These previous studies (Allen, 2017; Gallegos et al., 1994; Jordan et al., 2009; Leach et al., 1996a, 1996b; Shepardson, 2002; Strommen, 1995) either sampled only in urban areas or did not indicate that they considered region of living in the sampling process. An insight into how young children are inaccurate in their food chain concepts was provided by the previous research (Allen, 2017; Gallegos et al., 1994; Jordan et al., 2009; Shepardson, 2002; Strommen, 1995). However, it is unclear why children make these inaccurate judgments and if these inaccuracies would be revealed if region of living was examined on a sample of rural children who presumably have more exposure to nature. In addition, there may be certain cognitive skills required to make accurate food chain judgments. Therefore, the next step involves examining the cognitive skills 4- to 6-year-old children may need to reason about a food chain.

Cognitive Skills Needed to Reason about Food Chains

This study also examined specific cognitive abilities that might impact how children reason about food chains and how these cognitive abilities might interact with children's region of living (i.e., rural and urban). Two cognitive abilities of particular interest were cognitive flexibility and serial order.

Cognitive Flexibility

Cognitive flexibility is one possible cognitive skill needed to reason about a food chain. Cognitive flexibility involves switching from one mental set to another and allows for numerous scenarios and solutions to be considered when problem-solving. Children with higher cognitive flexibility tend to perform better on cognitive tasks due to keeping the objective task present in mind while sifting through possible explanations (Dick, 2014). Cognitive flexibility is generally important for children's academic performance because many academic topics require children to shift between many different mental sets (e.g., spelling tests require students to listen to the words, write the words, and take grammatical rules about word tenses into account; Lubin et al., 2016). It stands to reason that cognitive flexibility is also important for learning within biological domains. In particular, cognitive flexibility could assist children in their ecological reasoning by allowing children to conceptualize and flexibly consider multiple characteristics of an organism at once. This would allow children with higher cognitive flexibility to have a more accurate understanding of the various interactions organisms in a food chain have with other organisms. Additionally, cognitive flexibility might lead children to have a more complete understanding of food chains by allowing children to switch between the different memberships (i.e., predator and prey) that an organism holds. Therefore, having higher cognitive flexibility might help children view one particular organism as an interdependent component of the ecosystem in that without both memberships (i.e., predator and prey) the food chain could not continue in the sequence.

One method that children's cognitive flexibility can be measured is through the Dimensional Change Card Sort (DCCS), which requires children to sort cards that match a target on one of two dimensions (i.e., color or shape). Children are first told a sorting rule to match the cards with the target by one dimension (e.g., color), but the rule changes during the testing period, and children are asked to sort the cards to the target by matching the other dimension (e.g., shape), requiring children to keep the most present rule salient (Kloo & Perner, 2005). Failure on the DCCS occurs when children fail to switch to the new rule (i.e., shape) and continue to sort by the old rule (i.e., color) which may be due to young children's inability to represent and use both roles simultaneously (Zelazo et al., 2003). This standard version of the DCCS is an appropriate measure of cognitive flexibility for 3- to 5-year-olds. Typically, 3-year-olds continue to sort by the old rule (i.e., color) during the post-switch phase and 5-year-olds change their sorting process to sort by the new rule (i.e., shape) during the post-switch phase (Zelazo et al., 2003). Like the DCCS, food chains require children to keep multiple dimensions (i.e., representations) in mind at once to see the connectedness of the ecosystem. This would require children to have higher cognitive flexibility to consider multiple categories (e.g., predator and prey) of the same organism (e.g., bird) at once. Therefore, cognitive flexibility might be needed for children to describe organisms' interactions and categories within food chains.

Memory for Serial Order

Another cognitive ability that could assist in children's understanding of ecological processes is serial order, which examines children's ability to represent and recall a sequence of items in a particular order. The structure of food chains (i.e., producer-primary consumer-secondary consumer-apex predator) is similar to serial order tasks (i.e., requires children to memorize and recall a list of five arbitrary items). Like serial order tasks, food chain knowledge includes recalling a list of organisms in a specific sequence and direction. Children as young as 4 years of age can learn a 5-element pattern in order, memorize the sequence, and recall it from memory (Holcomb et al., 1997; Terrace & McGonigle, 1994). Mature serial order abilities include being able to use inductive reasoning skills to complete the pattern from different starting points, with omitted elements, and bi-directionally (Gulya & Colombo, 2004; Holcomb et al., 1997; Terrace & McGonigle, 1994). Children 7 years of age and younger are rarely successful in completing the pattern from different starting points and with omitted elements (Holcomb et al., 1997). Children may become better at ecological reasoning with age because they develop the ability to use inductive reasoning within the context of ordered lists.

Indeed, similar to results found in serial order tasks, Gallegos et al. (1994) found 5- to 10-year-old children could also learn a five-element food chain pattern and recall food chain patterns from memory. However, children 5 years of age and younger were unable to understand each organism's labels (i.e., predator or prey) and placement on the food chain. Even in children's creation of food chains, young children typically build food chains by ranking animals from biggest to smallest, least important to most important, and maybe even least intelligent to most intelligent (Gallegos et al., 1994).

In serial order tasks, as with creating food chains, young children struggle with different starting points and excluding a component of the pattern (Gulya & Colombo, 2004; Holcomb et al., 1997; Terrace & McGonigle, 1994). An example of this would be taking our typical A-B-C-D-E pattern, in which each letter represents a distinct object (e.g., cat-book-tree-shoe-crayon) and testing whether children could finish the pattern starting at C, complete the pattern without using D, or recall the pattern backward by answering E-D-C-B-A. Children might need this serial order ability to complete and reason through food chains to understand organisms' interactions and relations with one another. This ability demonstrates that children understand the category memberships each organism has and comprehend the food chain order, thus intuiting what an organism eats and what will eat the organism.

Cognitive Skills in Food Chains

Using the example of an arctic food chain, plankton-krill-silverfish-seal-orca, each component represents an abstract concept of a population of organisms that way be a member of more than one category of either plant, animal, prey, predator, producer, herbivore, and/or carnivore. It could be that cognitive flexibility and serial order skills might be required to comprehend each organism's memberships correctly and the relationships organisms have with the other organisms within the food chain. Therefore, it could be that children will fail to hold two or more characteristics of an organism in mind at once if they are unable to demonstrate cognitive flexibility. For example, this would occur if children could not conceptualize the silverfish as being both a predator (i.e., eat other animals) and prey (i.e., eaten by other animals) animal.

Meunier and Cordier (2009) argue that younger children are more focused on the causal features rather than the effect features of reasoning. However, for children to be correct in their food chain reasoning they will need to recognize both the cause and effect features simultaneously. If children have sufficient serial order skills, they will be able to remember the entirety of the pattern from any given location and with the omission of elements. Children have an accurate understanding of food chains when they comprehend how organisms are relevant to one another in the sequence of the food chain. Therefore, young children may lack the cognitive flexibility and serial order abilities to conceptualize beyond the organisms' physical characteristics and location on the food chain.

Increased Exposure to Nature Among Rural Children

Due to increased exposure to nature, rural children might perform more accurately than urban children on food chain tasks despite possibly having lower cognitive flexibility and serial order abilities. It could be that rural children have underdeveloped cognitive flexibility and serial order abilities due to lower SES status and poorer quality of education (Best et al., 2011; Linebarger et al., 2014). Nevertheless, rural children's increased exposure to nature could be allowing these children to have experiences with food chain recognition that urban children lack (Cheng & Monroe, 2012).

Rural and urban communities have three potential differences in their exposure to nature. First, there are differences in the type of outdoor exposure across rural and urban areas. The naturalistic settings of rural communities typically include increased access to raw and untouched woods and farmland compared to urban communities that have access to structured nature settings such as constructed parks, gardens, and green spaces (Kaplan & Kaplan, 1989). Second, the difference in the time and frequency spent outdoors such that rural children might be spending more time outdoors compared to urban children. Finally, the type of time spent outdoors might differ across region of living. During play in nature, rural children are more likely to experience experiential learning, or free action, compared to urban children who are more likely to experience promoted action (Singer et al., 2009). Free action involves children exploring nature by themselves based on their curiosity and it develops intrinsic motivation to engage with and enjoy nature. Promoted action involves children learning about nature from a parent or educator in a structured setting (e.g., a zoo); this type of learning assists in the fundamental development of nature reasoning (Clayton, 2012; Reed, 1996). Although both types of learning are important, free action might allow rural children to hold a greater appreciation of nature (Singer et al., 2009).

The Present Study

The current study examined food chain knowledge among rural Appalachian children and urban-dwelling children. In general, the Appalachian people are a geographical and cultural group living among the Appalachian Mountains in the Eastern United States. Appalachia stretches across 13 states, including sections of northeastern North Carolina (a list of counties that are considered Appalachia in North Carolina can be found in Appendix D; Appalachian Regional Commission, 2021). The areas around the Appalachian Mountains contain more wildlife and naturalistic habitats, thus providing the Appalachian people with direct daily exposure to naturalistic settings. The participants in this study were North Carolinian children 4 to 6 years of age from rural Appalachian and urban Triad areas. The urban population was recruited from a relatively small geographical region surrounding the University of North

Carolina at Greensboro (the Triad area: Greensboro, High Point, and Winston-Salem). The same technique of convenience sampling was used for obtaining a rural population by recruiting from the subsection of the Appalachian region that was geographically closest to the University of North Carolina at Greensboro.

This study was designed to examine the possible relation between region of living and children's accuracy on an ecological food chain task. Cognitive flexibility and serial order skills were also measured to examine the relation between cognitive abilities and ecological food chain reasoning. Prior research in the environmental education literature has shown that children as young as 3 years of age can be taught and recall the justification for a three-element food chain, but they cannot describe the food chain interactions without first receiving an explanation from the experimenter (Allen, 2017; Leach et al., 1996a, 1996b). Additionally, environmental education research has shown that 7- and 8-year-old children tend to be able to explain food chains without the assistance of the experimenter (Gallegos et al., 1994). The present study used an age range of 4- to 6-year-olds because according to the previous literature, this age group should be able to assemble and describe their food chains with little help from the experimenter.

The present study adds further to the literature by examining whether rural children are more accurate in their reasoning about realistic organisms' qualities, interdependency, and predator/prey relations across a food chain. Within the environmental education literature, children's understanding of food chains has been assessed but only across food chains that the experimenter created for children during the testing session. These studies have shown how children reason about food chains made for them (Allen, 2017; Gallegos et al., 1994; Leach et al., 1996a, 1996b). The present study differed from this methodology by asking children to recapitulate food chains and explain their organism's placement after completion of a training trial with the experimenter. Previous measures relied on experimenter created food chains and assessed children's food chain justifications only. The present study added children assembling their own food chains to assess food chain conceptual knowledge.

Additionally, the present study is novel in that the stimulus of each organism is depicted by a realistic photograph. Previous studies have used black-and-white figures (Coley, 2012; Gallegos et al., 1994), 3-D models (Allen, 2017), and drawings (Leach et al., 1996a, 1996b). The purpose of portraying realistic organisms was so they would be familiar to the Appalachian children because the organisms would closely mimic those native to the biome that encompasses the rural Appalachian children's residency. This could indicate that rural Appalachian culture incorporates regular nature-based discussions with children from their family members, friends, and teachers. Another purpose of utilizing realistic organisms is to reduce the anthropomorphic reasoning that children often use when nature is portrayed unrealistically (Conrad, 2015; Legare et al., 2013).

Finally, a multilevel training period was implemented for the ecological food chain tasks. Children first completed the familiarization trial, the practice trial, the training trial, and then finally the test trials. The purpose of having the familiarization trial, practice trial, and training trial was to be sure children understood what a correct food chain order looked like and were given the correct justifications for the organism's placements. In the familiarization trial the experimenter showed children how to put the organisms in the correct order. The practice trial required children to individually place and justify the organisms on the food chain in the same way they would on the test trials. Then, in the training trial, the experimenter showed children how to place and justify the organism on the food chain correctly before the children completed the test trials.

The first hypothesis was that Appalachian children would be more accurate than urban children on the ecological food chain task because of their increased exposure to nature. The second hypothesis was that urban children's performance on the ecological food chain task would be related to their cognitive flexibility and serial order abilities, but that Appalachian children's ecological food chain performance would not rely on cognitive flexibility and serial order. It was hypothesized that Appalachian children would have higher performance on the ecological food chain task, regardless of their cognitive flexibility and serial order abilities, because of their increased exposure to nature. Particularly, it was hypothesized that Appalachian children would have higher performance on the ecological food chain justification questions due to an increased frequency of nature talk and exposure to nature. It was also hypothesized that older children would do better on the cognitive flexibility and serial order task due to age-related development. Thus, it was expected that older urban children would perform better on the ecological food chain task compared to younger urban children but that rural children would perform better than urban children regardless of their age due to the former's increased exposure to nature.

CHAPTER II: METHOD

Participants

A total of 94 4.0-to 6.9-year-old children participated in this study. However, two children (n = 1 urban 4-year-old and n = 1 urban 5-year-old) were excluded for inability to complete the ecological food chain task due to fussiness. Therefore, the data from 92 4.0- to 6.9-year-old children were included in the data analysis. An a priori power analysis using G*Power (Faul et al., 2009) was conducted with a predicted medium effect size of $f^2 = .15$ between the predictor of children's region of living and the outcome of children's ecological food chain task, yielding a power of .90 with a sample size of at least 90 participants.

Children's region of living was operationalized by determining the children's current geographical location by the ZIP code where the children lived. Following both the definitions of the Appalachian Regional Commission (2021) and the U.S. Census Bureau (2021), children were considered urban if their ZIP code was within the Triad (i.e., Winston-Salem, Greensboro, and High Point) or nearby area and had a population density greater than 600 people per square mile.

Children were considered Appalachian rural if their ZIP code was inside a county that was designated as part of the Appalachian region and included a population density of fewer than 500 people per square mile (Appalachian Regional Commission, 2021; U.S. Census Bureau, 2021; United States Postal Services & U.S. Census Bureau, 2022). ZIP codes by population, size, county, region of living, and sample frequency can be found in the table in Appendix D, along with the counties considered to be Appalachian.

Some children from urban populations were recruited from and tested in daycares, after school care programs, and local children's museums located in North Carolina's urban Triad areas (i.e., Greensboro, High Point, and Winston-Salem). Other children from urban populations were contacted through the Development and Understanding of Children's Knowledge (D.U.C.K.) lab database containing contact information for families recruited at community events; these children were tested in the D.U.C.K. lab. Children from Appalachia were recruited and tested only in daycares, after school care programs, community centers, and parks in rural North Carolina Appalachian areas. All participants received a small toy for their participation in this study.

Of the 92 4- to 6-year-old children who participated in this study, *n* = 47 resided in a rural Appalachian area and *n* = 45 resided in an urban Triad area. Information about biological sex distribution by region of living and age can be found in Table 1.

Table 1. **Frequency of Children's Biological Sex by Region of Living and Age**

	Female		Male	
	Rural	Urban	Rural	Urban
4-year-olds	10	9	7	6
5-year-olds	8	5	7	10
6-year-olds	8	4	7	11

Participants came from a total of 34 different ZIP Codes which were categorized as rural or urban based on the corresponding ZIP Code population density and county (See Appendix D). The urban counties included Durham (*n* = 1), Forsyth (*n* = 3), Guilford (*n* = 40), and Moore (*n* = 1). The rural counties included Alleghany (*n* = 3), Davie (*n* = 5), Forsyth (*n* = 4), Stokes (*n* = 6), Surry (*n* = 9), Wilkes (*n* = 8), and Yadkin (*n* = 12). Forsyth was the only county that could be categorized as either urban or rural depending on the ZIP Code provided by the parent.

As part of the demographic questionnaire, parents were asked about their children's ethnicity and race. Of the rural children 6.4% identified as Hispanic or Latinx, 10.6% identified as multi-racial, and 83% identified as White or Caucasian. Of the urban children 11.1% identified as Hispanic or Latinx, 6.7% identified as African American or Black, 11.1% identified as Asian, 13.3% identified as multiracial, and 57.8% identified as White or Caucasian. A Chi-Square revealed rural areas were associated with a higher probability of being White, χ^2 (1, N = 92) = 7.32, p = .007. All parents were asked to fill out demographic information about annual household income and the father's and mother's highest education level. See Table 2 for parents' responses.

Table 2. Demographic Data Based on Region of Living

	Mother Education Level		Father Education Level	
	Rural	Urban	Rural	Urban
No High School	1	0	0	2
High School/GED	5	0	12	2
Associate Degree	7	0	4	1
Some College	12	5	8	5
Bachelor's Degree	13	15	14	12
Some Graduate School	1	3	1	1
Graduate Degree	6	16	4	14

Annual Household Income	Rural	Urban
Less than $15,000	0	0
$15,000-$24,999	1	10
$25,000-$39,999	4	0
$40,000-$59,999	2	2
$60,000-$89,999	10	7
$90,000-$120,000	6	11
Greater than $120,000	9	18
Prefer not to respond	14	4

Note. Variation in sample sizes was due to parental choice to answer all or none of the provided questions. Rural Mother Education n = 45, Rural Father Education n = 43, Rural Annual Household Income n = 46, Urban Mother Education n = 39, Urban Father Education n = 37, Urban Annual Household Income n = 42

Materials

Ecological Food Chain Task

The materials for the ecological food chain task included a total of 18 photographs of organisms (see Appendix A). Six of the photographs were components of two three-element food chains that were used in both the familiarization and training trials. The remaining photographs were components of three four-element food chains that were used in the testing trials. All the photographs were realistic and of organisms that can be found within the deciduous forest biome that depict the wildlife living in the Appalachian region. The photographs were printed out, laminated, and 5 in x 3.33 in. The photographs had Velcro attached to the back of them, so that they could be placed on a 20 in x 10 in board that folded out with four numbered slots.

DCCS Task (Cognitive Flexibility)

The DCCS task was administered on a laptop and was programmed through the software PsyToolKit (Stoet, 2010, 2017). The stimuli for the DCCS task were displayed on the laptop screen; they included a red train, blue star, blue train, and red star (see Appendix B). All of the stimuli were 2.5 in x 2.5 in and children sat 18 inches away from the screen.

Serial Order Task

The stimuli of the serial order task included pictures of six characters from the children's TV show SpongeBob SquarePants: Mr. Krabs, Patrick, Sandy, Squidward, Plankton, and SpongeBob (see Appendix C). All of these photographs were printed out, laminated, and 4 in x 4 in. The SpongeBob card was attached to a popsicle stick.

Procedure

Before participation in the study, parents signed the consent form and completed the demographic questionnaire for their children. The demographic questionnaire collected information about the children's biological sex, race, ethnicity, parents' education, annual household income, children's exposure to nature, and the ZIP code in which children reside. All participants received the ecological food chain task, cognitive flexibility task, and serial order task in a randomized order. Including all tasks, participants typically took between 12-18 minutes to complete the study. All testing sessions were recorded using a video camera.

Measures

Defining Children's Exposure to Nature

Children's exposure to nature was determined by the parent's report of how much time children spend outside weekly, the frequency of nature talk, and the outdoor area surrounding children's residency. Parents were asked "How many hours a week does your child spend outside?" and provided with an open-ended response. Next, parents were asked, "How frequently do you talk about nature (i.e., food chains, predator/prey relations, and animal extinction) with your child?" and responded on a 5-point Likert scale (i.e., never, rarely, sometimes, often, everyday) for the question. Lastly parents were asked, "What type of outdoor exposure is directly surrounding the area in which you live?" and were given a set list of options (i.e., green space, garden, park, yards/golf course, woods, none).

Ecological Food Chain Task (adapted elements from Allen, 2017; Gallegos et al., 1994; Leach et al., 1996a, 1996b)

Familiarization Trial

The experimenter began by stating, "Today we're going to play the animal game, I'm going to show you some pictures of plants and animals. I am going to tell you the animals' and plants' names, and then I'm going to put them in order! Then I'm going to give you some pictures of plants and animals, tell you their names, and then you're going to put them in order. Are you ready to get started?" Children were given the pre-test familiarization trial with realistic photographs of a carrot-brown bunny-red fox (see Appendix A). The board was folded out to show only the first three numbered spots. The experimenter showed children each of the organisms by placing them in front of children where they could see all the photographs at the same time. As the experimenter showed children each card the experimenter labeled each organism with their respective name. Once children saw all the organisms the experimenter placed each organism in their assigned spot and said, "I'm going to put the carrot in spot number one, the brown bunny in spot number two, and the red fox in spot number three." The experimenter transitioned to the practice trial and said, "Okay now you're going to put some plants and animals in order like I did, but you're going to have four! I will still tell you their names, but this time you're going to put them in order." The experimenter then added the number four spot to the board.

Practice Trial

Children randomly received one of the three food chains, the other two were saved for the test trials. The experimenter began the practice trial by showing and labeling each organism in a randomized order. Once the experimenter finished labeling the organisms and laying them out on the table in front of children the experimenter said, "Can you put these plants and animals in order like I did?" The experimenter waited until the children set all the plants and organisms in a numbered spot.

Once children were done, the experimenter pointed to the organism that children put in spot number one and asked, "Why did you put the [insert name] in spot number one?" Once children finished providing a response for their justification of putting the organism in spot number one the experimenter pointed to the organism children put in spot number two and asked, "Why did you put the [insert name] in spot number two?" Once children finished providing a response for spot number two the experimenter pointed to the organism children put in spot number three and said, “Why did you put the [insert name] in spot number three?” Once children finished providing a response for spot number three the experimenter pointed to the organism children put in spot number four and said, “Why did you put the [insert name] in spot number four?”

Once the children responded to the spot four question the experimenter pointed to the organism children put in spot number three and asked, how that organism was in spot number three and what allowed that organism to be in between the spot number two organism and the spot number four organism. For example, if children provided the correct Food Chain A (i.e., grass-mouse-black snake-hawk) the experimenter would say, “You put the black snake in spot number three it is behind the mouse in spot number two and before the hawk in spot number four. How can the black snake be in between the mouse and the hawk? What allowed the black snake to be between the mouse and the hawk?” Once the children responded the experimenter moved to the training trial.

Training Trial

The training trial differed from the familiarization and practice trials in that the experimenter provided children with the correct justifications for each organism. The training trial started with the experimenter labeling the organisms for the training trial food chain of grass-deer-black bear. The experimenter pointed to spot number one and said, “The grass goes in spot number one. Can you put the grass in spot number one?” The experimenter waited for the children to put the grass in spot number one. If children put the grass in spot number one the experimenter said, “Great job, that’s correct! The grass is a plant, so the grass goes in spot number one! Plants have leaves and/or fruits that animals eat!” If children put an incorrect organism in spot number one or did not put a card down the experimenter assisted children in putting the grass in spot number one and said, “The grass is a plant, so the grass goes in spot number one! Plants have leaves and/or fruits that animals eat!”

Next, the experimenter pointed to spot number two and said, “The deer goes in spot number two. Can you put the deer in spot number two?” The experimenter waited for the children to put the deer in spot number two. If children put the deer in spot number two the experimenter said, “Great job, that’s correct! The deer eats only plants, so the deer goes on spot number two! All animals that only eat plants go in spot number two.” If children put an incorrect organism in spot number two or did not put a card down the experimenter assisted children in putting the deer in spot number two and said, “The deer eats only plants, so the deer goes in spot number two! All animals that only eat plants go in spot number two.”

The experimenter then pointed to spot number three and said, “The black bear goes in spot number three. Can you put the black bear in spot number three?” If children put the black bear in spot number three the experimenter said, “Great job, that’s correct! The black bear eats the deer, so the black bear goes in spot number three. The animal that goes in spot number three can eat both plants and animals, but it goes behind both the grass (experimenter pointed to the grass in spot one) and the deer (experimenter pointed to the deer in spot two) because the black bear can eat both the grass and the deer.” If children did not put the black bear in spot number three the experimenter assisted children in placing the black bear in spot number three and said, “The black bear eats the deer, so the black bear goes in spot number three. The animal that goes in spot number three can eat both plants and animals, but it goes behind both the grass (experimenter pointed to the grass in spot one) and the deer (experimenter pointed to the deer in spot two) because the black bear can eat both the grass and the deer.”

Test Trials

The experimenter introduced the test trials by saying, "Okay, so now you are going to go two more times! I'm going to show you one plant and three animals and I will tell you their names and then I want you to put them in order like I did." The experimenter displayed the number four spot on the board and then the experimenter gave the children the set of cards in a random order and labeled each organism for the children. The test trials followed the same process as the practice trial and took place so that children were scored on two total four-element food chains. The correct order of each food chain and the photographs provided for each plant and animal is in Appendix A.

Coding Scheme and Scoring

Ecological food chain accuracy was scored similarly to other studies that have used it (Gallegos et al., 1994; Leach et al., 1996a, 1996b). Children were scored on the accuracy of each of their created food chains. Accuracy for this task was coded using a 4-point scoring guide. A score of 3 denoted a correct food chain, meaning children put all the elements of the food chain in the correct location. For example, the correct placement of Food Chain A is Grass-Mouse-Black Snake-Hawk. A score of 2 denoted a correct sequence of organisms in the incorrect direction or the misplacement of a pair of organisms. Using Food Chain A, the incorrect direction would be Hawk-Black Snake-Mouse-Grass and a misplaced pair of organisms would be Grass-Mouse-Hawk-Black Snake. A score of 1 denoted three organisms in the incorrect place. Using Food Chain A, a score of 1 could be Grass-Black Snake-Hawk-Mouse. A score of 0 denoted that all four organisms were in the incorrect place.

Children received accuracy scores for individual food chains as well as a total accuracy score across the two test trial food chains. Therefore, the lowest total accuracy score children could receive was a 0 while the highest total accuracy score (FC Accuracy) children could receive was a 6.

A justification score was formulated on how children justified the placement of each organism in their respective spots on the board. To be considered a correct justification answer, children's plant justification must include an animal eating the plant while children's animal justification must include the animal eating or being eaten by another animal. It is possible for children to provide the correct justification but have the organism in the incorrect placement on the food chain; in these cases, children still received full credit on their justification scores despite no credit on the accuracy score. If children gave a correct justification, they received a score of 1, otherwise, they received a score of 0. The justification for plant placement was not included in the total score, so in total each food chain had three justifications. Both test trial food chain justification scores were aggregated together to create a cumulative food chain justification score (FC Justification) that could range from 0 to 6.

The cognitive flexibility justification (FC Cog Flex) component was the children's responses to the characteristics that allowed the animal in spot number three to be between the two other animals. The correct justification for this question was either that the animal was eating one animal while being eaten by the other or that the animal was both the predator and prey. The two test trial food chains each had one FC Cog Flex question, therefore added together for a cumulative score range of 0 to 2.

Virtual Dimensional Change Card Sort Task (Doebel, 2020; Stucke et al., 2022)

The Virtual Dimensional Change Card Sort Task (Doebel, 2020; Stucke et al., 2022) was conducted through the program PsyToolKit (Stoet, 2010, 2017). This version of the Virtual Dimensional Change Card Sort Task differs from the standard DCCS by what dimension label is provided for each card during the pre-switch and post-switch trials. On the standard DCCS, intended for 3- to 5-year-old children, participants hear a label for each card based on the current dimension children are told to sort by (e.g., when sorting by the shape rule, the card is labeled as a train or star). The cards are labeled in the pre-switch trials by the pre-switch dimension (e.g., "Here is a train.") and labeled in the post-switch trials by the post-switch dimension (e.g., "Here is a red one."). However, in the Virtual Dimensional Change Card Sort Task participants hear labels for each card based on the pre-switch dimension only (i.e., color, "Here's a red one."), even during the shape rule post-switch. This makes the task more difficult because children have to inhibit the previous rule and ignore the label cue to sort by the post-switch dimension correctly. However, the purpose of this change was to allow the task to be more appropriate for the older age range of children who participated in this study.

Pre-Switch Test Trials

Before the pre-switch test trials, there was a practice trial to familiarize children with how to use the keys on the computer and correctly match cards by each color. Then the pre-switch test trials began with the experimenter saying, "Okay, now we are going to play for real. Go as fast as you can and try not to make any mistakes." If children did not respond within 10 seconds, they moved to the next trial automatically. Each card was labeled at the start of each trial (i.e., "Here is a [red/blue] one."). In this study color was always the pre-switch dimension. Once children responded, regardless of their response being correct or incorrect, they would hear a pleasant bell noise. Children completed 12 pre-switch test trials. At the end of the 12 trials, the screen displayed a smiley face.

Post-Switch Test Trials

The next trial proceeded with the following rules, "Okay, now we're going to play a new game. We're not going to play the color game anymore. No way! Now we are going to play a new game called the shape game! The shape game is different. In the shape game, all the trains go here (the top left train moves), and all the stars go here (the top right star moves). Okay, let's play!" The participant would then complete 12 post-switch test trials. In the post-switch test trials, each card continued to be labeled at the beginning of each trial but it was labeled by the items' color (not shape; i.e., "Here is a [red/blue] one!"). If children did not respond within 10 seconds, they moved to the next trial automatically. Once children responded, regardless of their response being correct or incorrect, they heard a pleasant bell noise. After the 12 post-switch test trials were completed the screen displayed a smiley face and the screen read "Wow that was fast, you win!" The children's responses were recorded as correct, incorrect, or timeout along with reaction time for each trial (Stucke et al., 2022).

Serial Order Task (adapted from Gulya & Colombo, 2004)

Practice Trial

The stimuli of the serial order task were characters from the children's TV show SpongeBob SquarePants. There were five characters assigned in a specific order: A (i.e., Mr. Krabs)-B (i.e., Patrick)-C (i.e., Sandy)-D (i.e., Squidward)-E (i.e., Plankton; see Appendix C). The experimenter introduced the serial order task by saying, "Now we are going to play the order game, but first we need to learn the rules. During this game, you will see five different characters: (experimenter pointed at each character for emphasis) Mr. Krabs, Patrick, Sandy, Squidward, and Plankton. I will first point to each character in a special order and then you will point to the characters in the same order. If you do the correct order SpongeBob will show he's happy by being waved around in the air." Whenever children completed a trial correctly, the experimenter waved the SpongeBob photo on a popsicle stick around in the air. Whenever children completed a trial incorrectly the experimenter repeated the trial from the beginning. The experimenter did not provide the participant with feedback, which is essential to the task because it examined children's utilization of inductive reasoning to recognize that they arranged the incorrect pattern. The experimenter started the practice trial by saying "I am going to point to a pattern, and I want you to point to the same pattern." The experimenter pointed to the pattern A-B and said the character's name while they pointed. Once the participant had correctly repeated a basic A-B order the experimenter waved the SpongeBob card. The same A-B pair was repeated three times and afterward, the experimenter said, "Good job, now we are going to move to longer patterns."

Training Trials

Participants were scaffolded to produce the pattern of A-B-C-D-E in order from beginning to end. The experimenter taught participants the pattern order by pointing to the stimuli. Anytime a participant correctly completed a training trial they received the positive feedback of SpongeBob being waved in the air. Anytime a participant incorrectly completed a trial they received no feedback (i.e., no SpongeBob being waved in the air) and restarted the trial. There were seven training phases and to pass each participant had to provide correct responses twice in a row to move forward (Gulya & Colombo, 2004). During Phase 1 the experimenter taught the A-B sequence. The experimenter reinforced the A-B sequence in Phase 2. The experimenter taught the A-B-C sequence in Phase 3. The experimenter reinforced the A-B-C sequence in Phase 4, but the stimuli were provided in a different spatial location. The experimenter models Phase 5 the same way as Phase 4, but instead, the experimenter told the participant “This time I will point to only the first character in the pattern, and you will point to the others from the pattern we just learned.” This required participants to recall the pattern themselves. During Phase 6 the experimenter followed the same procedure as Phase 5 but included the A-B-C-D sequence. Finally, in Phase 7 the experimenter included the full sequence of A-B-C-D-E. All children passed the training trials.

Test Trials

Next, participants were asked to respond to the ordered pairs of AB, AC, AD, AE, BC, BD, BE, CD, CE, and DE. The order in which the participants received the test trials was randomized. The experimenter started the test trial by saying, “Now we’re going to play the harder version of the game. I’m going to put some cards down and without me pointing to any of them, I want you to point to the pattern like the pattern you just learned. Now in some of these patterns, there will be cards missing. If a card is missing, I want you to point to the pattern and skip the missing card! Okay, do you understand how to play?” The experimenter paused and answered the participant's questions if they had any. The participants did not receive any feedback on whether they were correct or incorrect. If the participant correctly answered five or more of the tested patterns, they proceeded to generate the order by the trio patterns. The groups of trios consisted of ABC, ABD, ABE, ACD, ACE, ADE, BCD, BCE, BDE, and CDE; the ordering was randomized. To be scored correct, children had to point to or say the cartoon character’s name in order of the ABCDE sequence without mentioning the omitted characters. Children could receive a score out of 10 on both the pairs and trios. A total score was derived by adding the pair and trio scores together creating a score range of 0 to 20. If children did not receive a score of 5 or higher for pairs they did not complete and received a score of 0 for trios.

CHAPTER III: RESULTS

Throughout the analyses, a p-value of .05 or below was considered a significant result, and a p-value greater than .05 and less than .10 was considered marginally significant.

Exposure to Nature Questionnaire

Parents were asked three questions about nature exposure. Parents were asked "How many hours a week does your child spend outside?", "How frequently do you talk about nature with your child?", and "What type of outdoor exposure is surrounding the area in which you live?" Responses are in Table 3. There was no difference in the time rural parents (M = 11.50, s = 6.42) reported their children spent outdoors per week compared to urban parents (M = 9.96, s = 5.60), $t(82) = 1.16$, $p = .248$. The modal nature talk frequency for rural parents was daily, while the modal frequency for urban parents was often. To conduct a Chi-Square analysis, the data were further categorized by grouping answer choices never, rarely, and sometimes together as lower frequency of nature talk and grouping the answer choices often and daily together as higher frequency of nature talk. A Chi-Square test revealed there was no difference in the frequency of nature talk across rural and urban parents, χ^2 (1, N = 63) = .55, $p = .459$. It was observed that rural parents were more likely to report naturalistic settings of outdoor nature exposure near their residency, with a modal response of woods/farm, compared to urban parents who were more likely to report structured outdoor exposure, with a modal response of park.

Table 3. Frequency of Parent Nature Exposure Response Based on Region of Living

Frequency of Nature Talk			Type of Outdoor Exposure		
	Rural	Urban		Rural	Urban
Never	0	1	Green Spaces	0	4
Rarely	5	4	Gardens	0	2
Sometimes	7	4	Parks	0	12
Often	12	9	Yards	1	5
Daily	16	5	Woods/Farms	42	2

Note. Variation in sample sizes was due to parental choice to answer all or none of the provided questions. Rural Nature Talk n = 40, Rural Outdoor Exposure n = 43, Urban Nature Talk n = 23, Urban Outdoor Exposure n = 25

Ecological Food Chain Accuracy (FC Accuracy)

Across all participants, regardless of region of living and age, children put one of their two food chains in the correct order (M = 3.20, s = 1.85). For the accuracy score, tests of sample homogeneity revealed a violation of the homogeneity assumption (Levene's Test $F(5, 86) = 5.27$, $p < .001$ and Hartley's F-Max Test for heteroskedasticity $F(5, 86) = 5.12$, $p < .001$). Therefore, children's FC Accuracy scores were recoded as pass (i.e., 5 or above) or fail (i.e., 4 or below). A passing score required children to get both food chains right, or one food chain right and one pair of organisms in the other food chain incorrect.

First, a Chi-Square test of independence was conducted to examine the relation between region of living and children's FC Accuracy performance. There was no difference between rural and urban children's FC Accuracy performance, χ^2 (1, N = 92) = .02, p = .896. Next, a Chi-Square test of independence was conducted to examine the relation between age and children's FC Accuracy performance. Older children were more likely to pass the FC Accuracy compared to younger children who were more likely to fail, χ^2 (2, N = 92) = 13.04, p = .001. Lastly, three Chi-Square tests of independence were conducted to examine the relation between region of living and children's performance categories for FC Accuracy at each age group (i.e., 4-, 5-, and 6-year-olds). No significant differences were detected between urban and rural 4-year-olds for FC Accuracy performance, χ^2 (1, N = 32) = .008, p = .927, urban and rural 5-year-olds for FC Accuracy performance, χ^2 (2, N = 30) = .00, p = 1.00, nor urban and rural 6-year-olds for FC Accuracy performance, χ^2 (2, N = 30) = .00, p = 1.00.

Table 4. Frequency of FC Accuracy Performance Based on Region of Living and Age

	4-year-olds		5-year-olds		6-year-olds	
	Rural	Urban	Rural	Urban	Rural	Urban
Pass	1	1	5	5	8	8
Fail	16	14	10	10	7	7

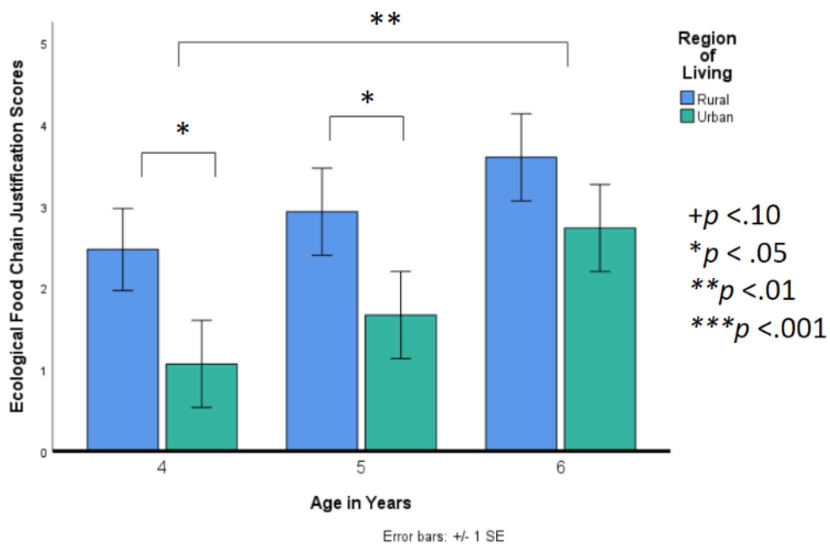
Ecological Food Chain Justification (FC Justification)

Across all participants, regardless of region of living and age, children were correct in two of their six food chain justification questions (M = 2.41, s = 2.18). Children received a separate score for their FC Justification which was determined from the reasoning children provided for their organism placements for spots two, three, and four. Children could receive a minimum score of 0 and a maximum score of 3 for the two test trial food chains, resulting in a cumulative minimum score of 0 and a maximum score of 6. A correct justification had to include the organism eating the organism in front (to the left) or being eaten by the organism behind (to the right). To ensure this coding method was reliable, intercoder reliability was assessed for 20%

of the participants where two coders coded the question and reached an agreement 96.5% of the time. When there was a disagreement, a third coder was used to resolve it.

For the justification score, tests of sample homogeneity (Levene's Test, $F(5, 86) = .70$, $p = .623$, and Hartley's F-Max Test for heteroskedasticity, $F(5, 86) = .46$, $p = .807$) revealed homogeneity can be assumed. Therefore, a 2 (region of living) x 3 (age in years) between-subjects ANOVA was conducted on children's FC Justification. The ANOVA revealed a main effect of region of living $F(1, 86) = 7.46$, $p = .008$, $\eta_p^2 = .080$ such that rural children ($M = 2.98$, $s = 2.09$) performed significantly better than urban children ($M = 1.82$, $s = 2.12$) on justifications. The ANOVA also revealed a main effect of age in years $F(2, 86) = 3.58$, $p = .032$, $\eta_p^2 = .077$. The Post Hoc LSD test revealed 6-year-olds ($M = 3.17$, $s = 2.07$) had significantly higher scores than 4-year-olds ($M = 1.81$, $s = 2.15$), $p = .012$, but there was no difference between 6-year-olds and 5-year-olds ($M = 2.30$, $s = 2.15$) nor between 4- and 5-year-olds. There was no significant interaction between region of living and age in years $F(2, 86) = .14$, $p = .870$, $\eta_p^2 = .003$. Notably, rural 4-year-olds' ($M = 2.47$, $s = 2.13$) and urban 6-year-olds ($M = 2.73$, $s = 2.28$) appeared not to differ in their ability to justify food chains.

Figure 1. FC Justification Based on Region of Living and Age in Years

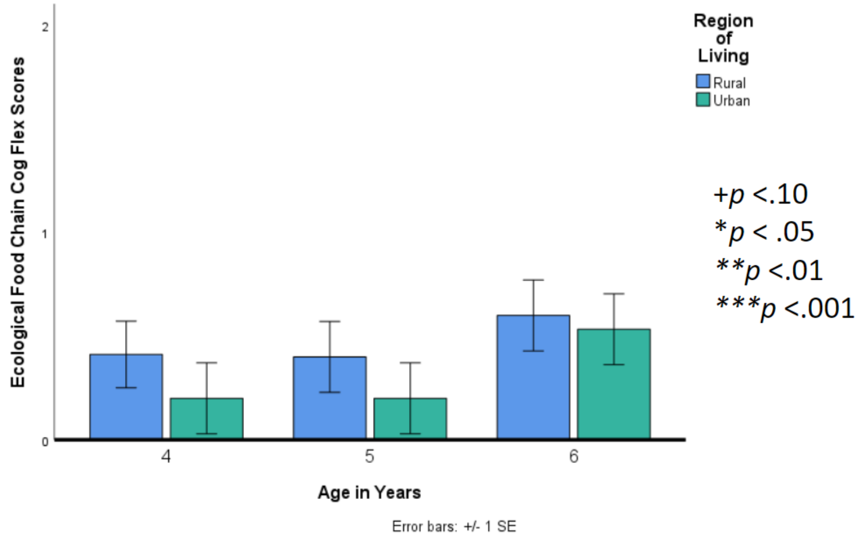


Ecological Food Chain Cognitive Flexibility Justification (FC Cog Flex)

Finally, I examined children's explanation of an animal that is categorized as both a predator and prey. There was only one question per food chain so children could receive a minimum score of 0 and a maximum score of 2. A correct FC Cog Flex must include an explanation of the animal eating the organism in front (i.e., to the left) and being eaten by the organism behind (i.e., to the right) or that the animal was both the predator and prey. To ensure this coding method was reliable, intercoder reliability was accessed for 20% of the participants where two coders coded the question and reached an agreement 94.7% of the time. When there was a disagreement, a third coder was used to resolve it.

Both Levene's Test, $F(5, 86) = .94$, $p = .461$, and Hartley's F-Max Test, $F(5, 86) = .34$, $p = .887$, revealed that homogeneity can be assumed. Therefore, a 2 (region of living) x 3 (age in years) between-subjects ANOVA was conducted to examine the effect on FC Cog Flex. The ANOVA displayed no effects of region of living, $F(1, 86) = 1.33$, $p = .253$, $\eta_p^2 = .015$, age in years, $F(2, 86) = 1.60$, $p = .209$, $\eta_p^2 = .036$, or interaction between region of living and age in years, $F(2, 86) = .11$, $p = .894$, $\eta_p^2 = .003$ on FC Cog Flex.

Figure 2. FC Cog Flex Based on Region of Living and Age in Years



Cognitive Flexibility (DCCS)

The DCCS measure is missing three rural participants (*n* = 1 rural 5-year-old and *n* = 2 rural 6-year-olds) because of the inability to establish an internet connection. Previously, the DCCS has been scored in a pass/fail manner because post-switch scores are typically bimodally distributed (i.e., children are either correct or incorrect on all post-switch trials; Zelazo et al., 2003). According to the binomial distribution, if children got 9 out of 12 trials correct there was only a 5.4% chance that children were guessing correctly. As a *p*-value greater than .05 and less than .10 was considered marginally significant in this study, I applied a passing criterion of 9 out of 12 for both the pre-switch and post-switch phases. Children that failed the pre-switch (*n* = 7) were removed from the post-switch analysis because cognitive flexibility cannot be assessed unless there is an established response set. Thus, the children that failed the pre-switch would perform better on the post-switch trial without understanding the rules of the task.

A Chi-Square test of independence was then conducted to examine the relation between region of living and children's performance categories (i.e., pass or fail) for the DCCS. Urban children were more likely to fail the DCCS post-switch while rural children were more likely to pass, χ^2 (1, N = 82) = 4.94, *p* = .026. A Chi-Square test of independence was then conducted to examine the relation between age in years and children's DCCS performance. There was no relation between children's performance and age in years, χ^2 (2, N = 82) = .76, *p* = .683. Lastly, three Chi-Square tests of independence were conducted to examine the relation between region of living and children's performance categories for DCCS post-switch at each age group (i.e., 4-, 5-, and 6-year-olds). There was no difference between 4-year-old urban and 4-year-old rural children's DCCS post-switch, χ^2 (1, N = 27) = 1.90, *p* = .168. Five-year-old urban children were more likely to fail the DCCS post-switch compared to 5-year-old rural children, χ^2 (1, N = 28) = 9.40, *p* = .002. There was no difference between 6-year-old rural and 6-year-old urban children's DCCS post-switch, χ^2 (1, N = 27) = .27, *p* = .603. Biological sex (girls = 1; boys = 2) was found to be positively correlated with children's DCCS post-switch (see Table 6). A Chi-Square test of independence revealed that regardless of region of living and age, boys were more likely to pass the DCCS post-switch compared to girls, χ^2 (1, N = 82) = 4.83, *p* = .028. It was found that 62.2% of boys and 37.8% of girls passed the DCCS post-switch.

Table 5. **Frequency of DCCS Performance Categories Based on Region of Living and Age**

	4-year-olds		5-year-olds		6-year-olds	
	Rural	Urban	Rural	Urban	Rural	Urban
Fail	6	9	2	11	6	6
Pass	8	4	11	4	6	9

Serial Order

Both pairs and trios were scored 0 to 10 and the total was derived by adding the pair and trio scores together creating a score range of 0 to 20. If children did not receive a score of 5 or higher for pairs they did not complete the trios and received a score of 0 for trios. Tests of sample homogeneity (Levene's Test, $F(5, 86) = .47$, $p = .796$, and Hartley's F-Max Test, $F(5, 86) = .40$, $p = .846$) revealed that homogeneity can be assumed. Therefore, a 2 (region of living) x 3 (age in years) between-subjects ANOVA was conducted to examine the effect on children's serial order total scores. The ANOVA revealed no effects of region of living, $F(1, 86) = .70$, $p = .405$, $\eta_p^2 = .008$, age in years, $F(2, 86) = .88$, $p = .420$, $\eta_p^2 = .020$, or interaction between region of living and age in years, $F(2, 86) = .20$, $p = .816$, $\eta_p^2 = .816$. No effects of region of living and age in years were revealed when pairs and trios scores were examined separate from one another. Biological sex (girls = 1; boys = 2) was found to be negatively correlated with children's serial order scores (see Table 6). An independent sample t-test revealed that regardless of region of living and age, there is a significant difference in that girls ($n = 44$, $M = 13.86$, $s = 5.36$) performed better than boys ($n = 48$, $M = 11.54$, $s = 5.09$) on serial order, $t(90) = 2.13$, $p = .036$.

Figure 3. **Serial Order Total Scores Based on Region of Living and Age in Years**

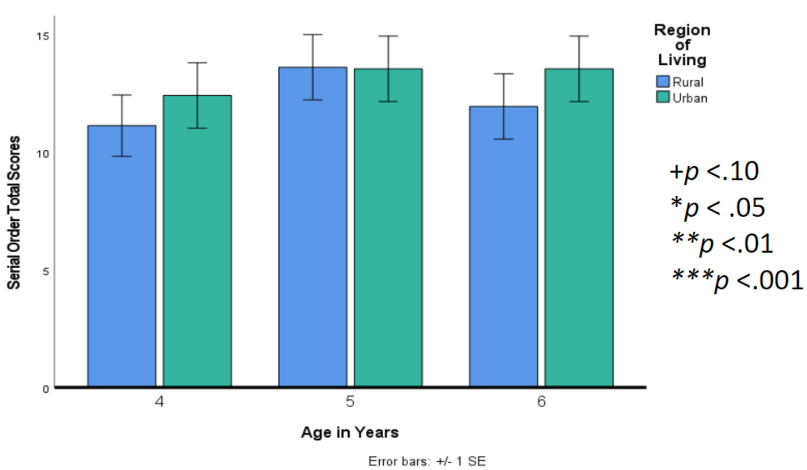


Table 6. **Pearson Correlations between Measure Variables, Region of Living, Age, and Biological Sex**

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Age	1	-	-	-	-	-	-	-	-	-
2. Region of Living	.061[a]	1	-	-	-	-	-	-	-	-
3. Biological Sex	.081[a]	.153[a]	1	-	-	-	-	-	-	-
4. Hours Outside	.129[c]	-.127[c]	-.137[c]	1	-	-	-	-	-	-
5. Nature Talk	-.005[e]	-.181[e]	-.094[e]	.068[e]	1	-	-	-	-	-
6. FC Accuracy	.288[a]**	-.223[a]*	.149[a]	.111[c]	-.171[e]	1	-	-	-	-
7. FC Justification	.287[a]**	-.267[a]*	-.038[a]	.103[c]	.069[e]	.609[a]***	1	-	-	-
8. FC Cog Flex	.227[a]*	-.119[a]	-.026[a]	-.069[c]	-.002[e]	.431[a]***	.665[a]***	1	-	-
9. DCCS post-switch	.064[b]	-.061[b]	.300[b]**	-.027[d]	-.004[f]	.074[b]	.115[b]	-.013[b]	1	-
10. Serial Order (SO)	.170[a]	.093[a]	-.219[a]*	.045[c]	-.062[e]	.077[a]	.097[a]	.117[a]	-.166[b]	1

Note. + $p < .10$, * $p < .05$, ** $p < .01$, ***$p < .001$; [a]$n = 92$, [b]$n = 89$, [c]$n = 84$, [d]$n = 81$, [e]$n = 63$, [f]$n = 60$

Regression Models

Bivariate correlations among age in months, biological sex (girls = 1; boys = 2), region of living (rural = 1; urban = 2), parent-reported number of hours spent outside per week, parent-reported frequency of nature talk (never = 1; rarely = 2; sometimes = 3; often = 4; everyday = 5), the three food chain measures, and two cognitive measures are presented in Table 6. Age and region of living are correlated with the FC Accuracy and FC Justification measures, indicating that older and rural children were more likely to perform better. All of the food chain measures were positively correlated with one another. FC Cog Flex was positively correlated with age. For the following analyses and tables, children who failed the DCCS pre-switch were included in the analysis by being assigned a score of 0 for the DCCS post-switch. The DCCS post-switch variable used in these regression models was childrens' raw scores. In addition to the Chi-Square tests for FC Accuracy and ANOVA analyses for FC Justification, a series of multiple regression models were conducted. The inclusion of the multiple regression models was to see whether cognitive flexibility and serial order were predictive of FC Accuracy or FC Justification above and beyond the other factors in the model.

Not all parents filled out the exposure to nature questions. Therefore, the same regression models were conducted with two samples to analyze the data with the full sample (*n* = 89) and the subsample (*n* = 59) that included children whose parents filled out the exposure to nature questionnaire. The full sample within the regression models is missing *n* = 3 rural participants due to inability to complete the DCCS. Additionally, for the subsample (*n* = 59) more rural parents (*n* = 36) filled out the nature questionnaire compared to urban parents (*n* = 23).

With data from the full sample, FC Accuracy was regressed on region of living (RoL), age in months, cognitive measures (i.e., DCCS post-switch and serial order total), the interaction between region of living and DCCS (RoLXDCCS), and the interaction between region of living and serial order (RoLXSO) using a Multiple Linear Regression Model (Table 7). The regression model revealed a significant effect of age, $b = .052$, $t(89) = 2.738$, $p = .008$, and a marginal effect of region of living, $b = -2.069$, $t(89) = -1.776$, $p = .079$, on FC Accuracy. As I used Type III Sums of Squares, I can conclude that age and region of living predicted FC Accuracy above and beyond the other predictor variables.

Table 7. Multiple Linear Regression Model: Full Sample on FC Accuracy

	F (*p*-value)	R^2	
Model 1	2.574 (.025)	.158*	
	b	SE	*t* (*p*-value)
(Constant)	2.487	2.112	1.177 (.242)
Region of Living	-2.069+	1.165	-1.776 (.079)
Age	.052**	.019	2.738 (.008)
DCCS post-switch	-.136	.119	-1.144 (.256)
Serial order	-.044	.117	-.375 (.708)
RoLXDCCS	.106	.077	1.379 (.172)
RoLXSO	.043	.072	.602 (.549)

Note. ***$p < .001$, **$p < .01$, *$p < .05$, +$p < .10$; $n = 89$.

Within the subsample of participants whose parents filled out the exposure to nature questionnaire, FC Accuracy was regressed on region of living, age in months, cognitive measures (i.e., DCCS post-switch and serial order total), the interaction between region of living and DCCS (RoLXDCCS), the interaction between region of living and serial order (RoLXSO), Hours Outside and Nature Talk using a Multiple Linear Regression Model (Table 8). Age significantly predicted FC Accuracy, *b* = .084, *t*(59) = 3.470, *p* = .001, while no other predictor variable was found to be significant in the model. As I used Type III Sums of Squares, I can conclude that age predicted FC Accuracy above and beyond the other predictor variables.

Table 8. Multiple Linear Regression Model: Nature Questionnaire Subsample on FC Accuracy

	F (*p*-value)	R^2	
Model 1	2.233 (.040)	.259*	
	b	SE	*t* (*p*-value)
(Constant)	1.952	2.372	.823 (.414)
Region of Living	-1.900	1.512	-1.256 (.215)
Age	.084**	.024	3.470 (.001)
DCCS post-switch	-.106	.136	-.775 (.442)
Serial order	-.081	.134	-.603 (.549)
RoLXDCCS	.118	.096	1.234 (.223)
RoLXSO	.034	.090	-.382 (.704)
Nature Talk	-.286	.215	-1.329 (.190)
Hours Outside	-.016	.040	-.411 (.683)

Note. ***$p < .001$, **$p < .01$, *$p < .05$, +$p < .10$; $n = 59$.

With data from the full sample, FC Justification was regressed on region of living, age in months, DCCS post-switch, serial order, RoLXDCCS, and RoLXSO using a Multiple Linear Regression Model (Table 9). It was revealed that region of living, *b* = -2.963, *t*(89) = -2.207, *p* = .030, and age, *b* = .069, *t*(89) = 3.162, *p* = .002, significantly predicted FC Justification.

Table 9. Multiple Linear Regression Model: Full Sample on FC Justification

	F (*p*-value)	R^2	
Model 1	3.580 (.003)	.208**	
	b	SE	*t* (*p*-value)
(Constant)	1.873	2.434	.770 (.444)
Region of Living	-2.963*	1.342	-2.207 (.030)
Age	.069**	.022	3.162 (.002)
DCCS post-switch	-.053	.137	-.388 (.699)
Serial order	-.133	.135	-.982 (.329)
RoLXDCCS	.063	.088	.711 (.479)
RoLXSO	.101	.083	1.216 (.228)

Note. ***$p < .001$, **$p < .01$, *$p < .05$, +$p < .10$; $n = 89$.

With data from the subsample, FC Justification was regressed on region of living, age in months, DCCS post-switch, serial order, RoLXDCCS, RoLXSO, Hours Outside, and Nature Talk using a Multiple Linear Regression Model (Table 10). It was revealed that age, $b = .087$, $t(59) = 2.969$, $p = .005$, significantly predicted FC Justification. Region of living, $b = -3.234$, $t(59) = -1.766$, $p = .083$, marginally predicted FC Justification. Therefore, from the Type III Sums of Squares, it can be concluded that age and region of living predicted FC Justification above and beyond the other predictor variables.

Table 10. Multiple Linear Regression Model: Nature Questionnaire Subsample on FC Justification

	F (*p*-value)	R^2	
Model 1	2.168 (.046)	.254*	
	b	SE	*t* (*p*-value)
(Constant)	.652	2.872	.227 (.821)
Region of Living	-3.234+	1.831	-1.766 (.083)
Age	.087**	.029	2.969 (.005)
DCCS post-switch	-.144	.165	-.876 (.385)
Serial order	-.161	.163	-.986 (.329)
RoLXDCCS	.177	.116	1.526 (.133)
RoLXSO	.098	.109	.901 (.372)
Nature Talk	.068	.260	.262 (.794)
Hours Outside	.030	.048	.614 (.542)

Note. ***$p < .001$, **$p < .01$, *$p < .05$, +$p < .10$; $n = 59$.

There may be a concern about the subsample ($n = 59$) not being representative of the full sample ($n = 89$). To address this issue, I ran regression models of the subsample without the nature questionnaire variables (i.e., Hours Outside and Nature Talk) on FC Accuracy (see Table 11) and then FC Justification (see Table 12) to ensure that the subsample results are similar to the full sample results when the nature questionnaire is not included in either model. When examining the general pattern between the slopes of the predictors in these two models there were no noticeable differences between the subsample including the nature variables in the predictors (see Table 7 for FC Accuracy, see Table 9 for FC Justification) compared to the models of the subsample not including the nature variables in the predictors (see Table 11 for FC Accuracy, see Table 12 for FC Justification). This suggests that the subsample is representative of the results of the full sample.

Table 11. Multiple Linear Regression Model: Subsample on FC Accuracy (No Nature Questions)

	F (*p*-value)	R^2	
Model 1	2.928 (.013)	.192*	
	b	SE	*t* (*p*-value)
(Constant)	1.694	2.134	.794 (.430)
Region of Living	-1.726	1.171	-1.473 (.145)
Age	.060**	.019	3.118 (.003)
DCCS post-switch	-.125	.120	-1.037 (.303)
Serial order	-.036	.117	-.308 (.759)
RoLXDCCS	.113	.078	1.458 (.149)
RoLXSO	.024	.072	.330 (.743)

Note. ***$p < .001$, **$p < .01$, *$p < .05$, +$p < .10$; $n = 59$.

Table 12. Multiple Linear Regression Model: Subsample on FC Justification (No Nature Questions)

	F (*p*-value)	R^2	
Model 1	3.295 (.006)	.211**	
	b	SE	*t* (*p*-value)
(Constant)	1.132	2.554	.443 (.659)
Region of Living	-2.590+	1.402	-1.848 (.069)
Age	.073**	.023	3.206 (.002)
DCCS post-switch	-.014	.144	-.098 (.922)
Serial order	-.131	.140	-.937 (.352)
RoLXDCCS	.049	.093	.530 (.598)
RoLXSO	.094	.086	1.095 (.277)

Note. ***$p < .001$, **$p < .01$, *$p < .05$, +$p < .10$; $n = 59$.

CHAPTER IV: DISCUSSION

The purpose of this study was to examine whether region of living, age, and cognitive abilities (i.e., cognitive flexibility and serial order) are associated with children's understanding of ecological food chains. In partial support of my hypothesis, it was found that rural children are more accurate in justifying food chains, but not producing food chains. These results are consistent with previous research that concluded that region of living (Coley, 2012; Ross et al., 2003) and exposure to nature (Cheng & Monroe, 2012; Eder, 1996; Khan, 1999) are important factors in the development of children's ability to reason about nature. Rural 4-year-olds appear to justify food chains as accurately as urban 6-year-olds. This suggests that rural communities may have a cultural or geographical component that increases children's food chain justification abilities. The current study expands upon this previous work in several novel ways. First, children in the current study produced their own food chains and then provided justifications for their reasoning in their organism placement. By contrast, previous studies provided children with food chains and asked children how organisms could be where they were (Allen, 2017; Gallegos et al., 1994; Leach et al., 1996a, 1996b). This methodological change allowed for further examination into the type of inferences children make about the biological world. On average, regardless of region of living and age, this study found that children got 40.2% of their food chain justification questions correct. This is a similar percentage reported in previous studies that found 3- to-5-year-olds were 50% accurate at identifying an organism as a carnivore and 43% accurate at identifying an organism as a herbivore (Allen, 2017). Additionally another study found that 3rd and 4th graders were 66.7% accurate at identifying predator-prey relations within food chains (Gallegos et al., 1994). The current study differed by asking children a more general question, “Why did you put this animal here?” compared to other studies that asked children a more direct question like, “What does this animal eat?” (Allen, 2017; Gallegos et al., 1994).

Second, the current study was novel in its use of realistic photographs. Previous studies examined children’s inferences about pseudo qualities (Coley, 2012) utilizing black-and-white figures (Coley, 2012; Gallegos et al., 1994), 3-D models (Allen, 2017), and drawings (Leach et al., 1996a, 1996b). The food chains designed for this study consisted of organisms native to the biome where the rural sample resided. Previous research supports that realistic animal depictions lead children to foster more accurate claims about animals which is often counter to animal portrayal in children’s media (Conrad, 2015). Thus, the use of realistic stimuli in the food chains was important when considering the amount of realistic exposure to nature children are gathering to support their formation of accurate animal reasoning. It might be that realism is more important in rural children’s formation of animal reasoning because of their heightened naturalistic exposure to nature compared to urban children. However, it still might be possible that rural children’s performance would be similar had the stimuli been non-realistic.

Third, children’s exposure to nature was assessed directly. Rural children’s increased exposure to nature has been suggested to be the main factor in fostering accurate conceptions of plants and animals (Coley, 2012; Duron-Ramos et al., 2020; Gallegos et al., 1994; Ross et al., 2003), but other than distinguishing between rural, suburban, and urban communities, these studies rarely provide reports on how increased exposure to nature was operationalized. To examine the possible differences across regions, I assessed increased exposure to nature through parent reports of their frequency of nature talk with their children, the average number of hours spent outside per week, and the type of nature surrounding their residency. Although parent reports are an indirect measurement, the purpose was to see whether parents from different regions subscribed to the stereotypical nature exposures of their residency (e.g., urban parents rarely talk about nature with their children, spend less time outdoors, and their children's nature exposure predominantly occurred in a park). Parent reports suggested possible explanations as to whether it was the exposure to nature or the cultural differences from regional practices that impacted children's knowledge of food chains.

Results from the current study suggest that urban and rural children did not differ in their frequency of nature talk or the average number of hours spent outside per week. It was observed in this study that the homes of rural children were more likely to be surrounded by farmland or woods compared to urban homes residing near parks. The surrounding environment might not change the quality of nature talk or time spent outside, but it could change the types of conversations that parents have with their children. Naturalistic settings (e.g., farmland and woods) likely inspires different types of nature conversations compared to the curated nature settings (e.g., parks) that urban children spend more time in. These conversations, in turn, may lead to more accurate food chain justifications in rural populations. Rural communities could also have a geographical or cultural component (e.g., hunting, fishing, and farming) that differentiates the nature talk that rural families are implementing in their conversations with their children, further increasing their ecological reasoning abilities.

There was some indication of the differences in nature conversations across region of living within the anecdotal explanations children used for their food chain justifications. When analyzing children's organism justification for the food chain task, I found anecdotal evidence that rural children are more likely to mention personal experiences with, and often conversations about, the animals presented. These responses often included fear and safety-based commands about the predators of their region. Many included explanations that their parents, peers, and community members had shared with them. For example, some responses from rural children include, “Coyotes live on the ground and it eats people.”, “Snake slithers and it’s bad. Because it bites. And my mom says if it bites you, you’ll die.”, “One of my mom’s brothers shot a coyote.”, “Is this one nice snake? Some snakes are really mean and not very nice.”, “The snakes that bite your whole hand off.”, “Coyotes hunt down kids.”, “You know which one my dad tried to kill one time? The coyote.”, “Hawks can take persons away.”, “My dad had to hit the raccoon with a boot.”, “My friend got bit by a coyote.”, “Snake eats humans.”, and “Bears eat people too.” None of the urban children provided personal anecdotes of the organisms eating or harming people, or people having to protect themselves against the animals.

A final novel contribution of the current study is the inclusion of cognitive flexibility and serial order measures to examine the cognitive skills that could assist in children’s organism placements and justifications across a food chain. I hypothesized that rural children’s performance on the cognitive tasks would not predict their performance on the ecological food chain task, but that cognitive tasks would be predictive for urban children. It was thought that urban children may need to rely more on their cognitive skills to perform well on the ecological food chain task due to a lack of exposure to nature. Neither serial order nor cognitive flexibility were predictive of children’s performance on the ecological food chain task. Thus, these findings do not support the original hypothesis.

It was found that urban children’s ecological food chain task performance did not relate to their cognitive flexibility nor serial order performances. Counter to the original hypothesis, 5-year-old rural children outperformed 5-year-old urban children on the DCCS. It was also found that boys were more likely to perform better than girls on the DCCS post-switch. This is contrary to previous findings of girls typically outperforming boys on cognitive flexibility tasks due to increased inhibitory control, thus remaining more focused on the task at hand (Doebel & Zelazo, 2015; Memisevic & Biscevic, 2018). One possibility is that 5-year-old rural children and boys increased performance on the DCCS was because these children were not attending to the misleading cue (i.e., labeling the post-switch phase by the pre-switch dimension) therefore they were not persuaded by the wrong label. However, it is possible that in certain contexts rural children and boys demonstrate higher cognitive flexibility. Additionally, the age-related effect from the Virtual DCCS (Doebel, 2020; Stucke et al., 2022) did not replicate in this task.

Children's serial order performance revealed no differences between region of living nor age. Serial order performance also did not relate to cognitive flexibility nor ecological food chain performances. However, it was found that girls had increased serial order performance compared to boys. It has been previously reported that preschool-aged girls have increased visual and verbal memory performance compared to boys (Visu-Petra et al., 2008; Voyer et al., 2017). Gulya and Colombo (2004) found that children younger than 5 years of age are unable to recall serial order pairs successfully. However, in this study it was found that there was no difference among 4- to 6-year-olds' ability to recall pairs or trios. It could be that 4-year-old children in this sample performed better than the 4-year-olds in the study conducted by Gulya and Colombo (2004) due to a cohort effect. Completed nearly 20 years ago, as an online study, it is possible that the 4-year-olds in Gulya and Colombo's (2004) study actually underperformed on their serial order abilities because of their lack of technological experience. Children are more proficient and comfortable using technology now than they were when Gulya and Colombo conducted their study in 2004. In 2000 only 41.5% of United States households had access to the internet, but 76.7% of households had access to the internet by 2014 (Konca, 2022). Currently, on average children 8 years of age and younger spend 2.30 hours of screen time a day and 40%

of children younger than 2 years already use mobile devices (Monteiro et al., 2022). Similar to children's cognitive flexibility performance, children's serial order performance did not relate to children's ecological food chain performance. Cognitive abilities such as cognitive flexibility and serial order may be still assisting in children's performance on the food chain task, but the cognitive tasks were not sensitive to measuring these abilities in this study.

I further examined the potential role of cognitive flexibility in food chains by measuring children's ability to recognize the third element organism in the food chain as both a predator and prey. It was hypothesized that rural children would have an increased understanding of the multiple roles (i.e., predator and prey) the third element organism could have in the food chain. Although rural children performed better overall on food chain justification, there was no performance difference across region of living for the food chain cognitive flexibility element. This is consistent with previous research, which suggests that children are only able to consider one role or niche of an organism in the food chain (Allen, 2017; Shepardson, 2002). Perhaps this is because children remain saliently focused on only one characteristic of the organism after putting the organisms in a sequence and describing the sequence incrementally. It might be that the cognitive flexibility food chain question was too difficult for the 4- to 6-year-olds. It could also be that cognitive flexibility is not essential for reasoning about ecological food chains.

First conducted by Inhelder and Piaget (1958), the matrix task required children to justify how the correct item could be in the spot that it was. In this task, children had to simultaneously categorize on two dimensions (i.e., shape and color; Bart & Airasian, 1974). Children under 6 years of age could provide one correct dimension, but rarely could they provide the answer that was correct for both dimensions. Often when children had provided the correct item, they still only described the item as matching the pattern of one dimension (Chen et al., 2016). This could explain why it is difficult for children to have flexible thinking about an animal as having multiple memberships (i.e., predator and prey). Typically, children associate a single membership to an animal (i.e., predator or prey). Similar to the ecological food chain cognitive flexibility, it could be beyond these children's cognitive abilities to explain an item or organism by both dimensions or memberships at the same time.

Allen (2017), Leach et al. (1996a, 1996b), and Shepardson (2002) used samples that included children 6 years of age and younger and concluded that children did not have the reasoning abilities to explain food chains beyond describing how the organism next in the food chain eats the organism in front of it. For example, with the food chain grass-deer-bear, children would only be able to reason that the deer eats the grass and the bear eats the deer. Children would not be able to reason the grass is eaten by the deer and the deer is eaten by the bear. Children would also not be able to reason that the deer is the only organism eating and being eaten in this food chain example. Because the findings of Allen (2017), Leach et al. (1996a, 1996b), and Shepardson (2002) were not inclusive of a variable examining region of living. Therefore, I hypothesized rural and older children would be able to categorize the secondary consumer as being both a predator and prey animal. Although the 4- to 6-year-olds in the current study were able to reason about animals being a predator or prey, it could be that it was still beyond their cognitive abilities to characterize the third element organism as both a predator and prey. These findings suggest the theories described previously by Atran (1990) and Carey (2000) withstand as true in describing children's inflexibility in their thinking of a secondary consumer in this study. These children are not inferring the biological features of similar organisms as previously argued by Gutheil et al. (1998). Instead, children are failing to be flexible in their representation of the organism by not applying more than one membership to the organism at once. This supports the previous researchers (Gallegos et al., 1994; Jordan et al., 2009; Strommen, 1995) in that 4- to 6-year-olds are able to memorize the sequence of a food chain, but contrary to their findings these children understand a single role or membership that each organism holds at the different spots on the food chain. Thus, it is still possible that in slightly older children a rural advantage develops earlier for categorizing an organism as both a predator and prey.

Previous research suggests that after 5 years of age children's performance on food chain tasks greatly increases (Allen, 2017). Also, Coley (2012) found that older children (ages 6-, 8-, and 10-year-olds) and rural children were more likely to infer biological characteristics about animals of similar taxonomic relation. Therefore, I hypothesized there would be an interaction between region of living and age for children's performance on both assembling and justifying food chains. However, it was found that older children performed better on assembling and justifying food chains compared to younger children, but there was no region of living difference on assembling food chains, only justifying food chains. Therefore, these findings align with the theories previously described by Allen (2017) in that older children performed better than younger children on assembling food chains. The current study also showed similar age-related trends and region of living differences in that older children and rural children were better at describing the relation between animals of hierarchical taxonomic relations as suggested by Coley (2012).

Limitations and Future Directions

A possible limitation of this study was that the phrasing of the cognitive flexibility question in the food chain task (i.e., "How can this animal be in between these two animals?") did not probe children to provide the correct information. A similar question was also asked at the end of the other individual organism justification sections (i.e., "Why did you put this organism here?") which could have prompted confusion and led to inaccuracy in children's responses (i.e., carryover effect). For example, using the food chain grass-mouse-black snake-hawk a potential cognitive flexibility question could be, "What is different about the black snake that puts it between the mouse and the hawk?" This could enhance children's understanding that the experimenter is asking how the snake relates to both lower and higher order animals.

An additional future direction is to examine children's reasoning about food chains by assessing the types of conversations children are having about nature. Although the types of nature conversations were not assessed in this study, it was observed that rural children provided more anecdotal justification for their food chains. However, it was found that there was no difference between the frequency of nature conversation rural parents and urban parents have with their children. Therefore, it could be the type of conversations that rural parents are having that is fostering rural children to have better food chain task performance. It could be that the difference might arise from the types of examples and outdoor safety training that rural children are receiving in their conversations with parents, peers, and community members about nature. Future studies will have to be designed to directly explore the differences in nature-based conversations across rural and urban communities.

There was a limitation in that urban parents were less likely to fill out the exposure to nature questions. This decreased response rate was seen across the number of parents that filled out the hours spent outside (rural $n = 44$, urban $n = 40$), frequently of nature talk (rural $n = 40$, urban $n = 23$), and type of outdoor exposure (rural $n = 43$, urban $n = 25$) questions. The decreased response rate could be due to urban parents not wanting to reveal low levels of nature talk and less outdoor exposure to nature (i.e., selection bias). Therefore, although there was no difference between region of living on hours spent outside and frequency of nature talk, it is possible had more urban parents filled out those questions accurately that there would have been a significant difference among those variables.

The Virtual DCCS (Doebel, 2020; Stucke et al., 2022) was used in the current study and may have contributed to the null findings related to the measure of cognitive flexibility and the relation between cognitive flexibility and the ecological food chain task. In this version of the DCCS, the post-switch trial (i.e., shape) was labeled by the pre-switch dimension (i.e., color) which makes the task more difficult. Although previous research has demonstrated that this task is appropriate for the age range of this study (Doebel, 2020; Stucke et al., 2022), the results in the current study did not display typical age-related trends. Overall, the children in this sample performed worse than in previous studies with the Virtual Dimensional Change Card Sort Task (Doebel, 2020; Stucke et al., 2022). It was expected that most 4-year-olds would continue to sort during the post-switch phase (i.e., shape) by the pre-switch dimension (i.e., color) and most 6-year-olds would sort by the post-switch dimension (i.e., shape) during the post-switch phase. This sample could have performed differently because of the general geographical difference between both the urban and rural North Carolina region in comparison to the high SES and higher quality of early educational resources located in the Northern Virginia sample utilized by Doebel (2020). To examine this difference further, future studies using different cognitive flexibility measures should be conducted. As seen in this study, rural 5-year-olds performed better than urban 5-year-olds on the DCCS, this effect of region of living would most likely not present with a different cognitive flexibility task. Instead, I hypothesize with a different cognitive flexibility task no difference between region of living would be seen, but there would be an age effect of older children performing better than younger children.

The serial order measure had a limitation in that all children received the pattern of characters in the same order. In theory, any character could have been assigned the A-B-C-D-E role for the pattern, but it would have been best to randomize each character's placement in the pattern for each participant. Doing so would have ensured that the particular order of characters did not alter the children's task performance. However, it is unlikely that different orders would have mattered. This is because the pattern of the characters was arbitrarily assigned and not related to any characteristic of the characters.

Additionally, it is a limitation that each cognitive ability (i.e., cognitive flexibility and serial order) was measured with only one cognitive task. Due to the age group studied, only one cognitive measure per cognitive ability was utilized to accommodate a shorter attention span and limit the testing time frame to less than 20 minutes. This study examined only one element of executive function (i.e., cognitive flexibility), but it is likely other executive function abilities are contributing to children's performance on these tasks. Therefore, future studies need to incorporate other measures of executive function to distinguish better what cognitive abilities are important for reasoning about food chains. Previous research about how children reason about ecological food chains does not include cognitive baseline abilities. Therefore, the abilities that children might need for reasoning about ecological food chains had to be assumed in this study and not tested; it is possible that there are other cognitive abilities that are used in reasoning about food chains. This study aimed to establish a cognitive baseline for how 4- to 6-year-olds reason about food chains. Future research needs to replicate cognitive flexibility with a different measure such as the border version of the DCCS task because it has increased reliability in age-related findings (Zelazo, 2006) compared to the Virtual DCCS version. The border verison of the DCCS requires children to complete a pre-switch trial labeled by the pre-switch dimension (e.g., color), then a post-switch trial labeled by the post-switch dimension (e.g., shape). Finally, the border trial requires children to sort by color if there is a border around the card and to sort by shape if there is no border around the card. Children are not verbally given a label, but instead must remember the rule when sorting (Zelazo, 2006). The border version of the DCCS might be a better task for 4- to 6-year-old children because it is not providing a misleading cue like the Virtual DCCS. Additional future studies should consider different cognitive abilities, like working memory, that could explain children's ecological food chain performance. In the food chain task, children are given the correct justifications for organisms in the training trial. Therefore, children need to remember and apply the justification to their own food chains, thus using working memory.

Another future direction would be to incorporate a categorization task with a food chain task in a future study. Previous work in children's ecological reasoning has used categorization tasks like the Triad Task. Studies that have included ecological categorization tasks have revealed that rural children are more accurate at categorizing organisms of similar taxonomic relations compared to urban children (Coley, 2012). Although this study found that rural children are more accurate at justifying food chains compared to urban children, it is still not known if ecological categorization task performance relates to food chain task performance. Future work will have to establish whether ecological categorization tasks relate to ecological food chain tasks.

A final possible limitation is sampling error due to the recruitment technique for selecting children to participate in the study. The majority of the children in this study were recruited from local urban and rural daycares by sending consent forms home to parents to sign and return to the daycares. Young children in daycares are receiving increased structured learning compared to their peers that do not attend daycare. Therefore, this sampling method may have been selecting higher achieving urban and rural children, thus masking potential differences in region of living and age in the cognitive flexibility and serial order measures.

Conclusion and Implications

It was previously shown that children's experience with nature is an important factor in the development of children's biological knowledge (Cheng & Monroe, 2012; Kaplan & Kaplan, 1989). The present study is one of the first to provide empirical research about how differences in children's immediate surroundings within their region of living can impact their food chain justifications. Rural children's experiences in nature and conversations about nature may support more accurate food chain justifications and knowledge. Daily exposure to naturalistic settings received by rural children assists in increased knowledge of real world examples in food chain justifications. It was previously suggested that children 6 years of age and younger did not have the ability to explain experimenter created food chains (Allen, 2017; Leach et al., 1996a, 1996b; Shepardson, 2002). However, this study found that developmentally children are assembling food chains at the same age, but rural children's food chain justifications are developing at an earlier age. In support of Atran (1990) and Carey (2000) findings of children's categorization abilities, 4- to 6-year-olds failed to label an organism as having more than one membership simultaneously. In contrast to this study's hypothesis, it does not seem that cognitive flexibility and serial order abilities are impacting children's ecological food chain performance. Future studies will have to assess these and additional cognitive abilities to understand how children reason about food chains.

Lastly, future studies should include broader rural populations to increase generalizability in developmental findings for children residing in rural areas. Few studies have examined the differences in children’s ecological reasoning based on their region of living (Coley, 2012; Ross et al., 2003). These studies have recruited urban and rural populations from Wisconsin (Ross et al., 2003) and Massachusetts (Coley, 2012). Diverse rural populations need to be included in the recruitment and sampling processes of developmental studies beyond ecological reasoning. Currently, in psychological research rural populations are underrepresented.

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APPENDIX A: STIMULI FOR ECOLOGICAL FOOD CHAIN TASK

Figure A4. Stimuli for Familiarization Trial

Note. This figure displays the photographs used in the familiarization trial food chain. The number listed in the top right of each photograph shows the correct food chain sequencing. These numbers are not provided on the photograph given to the participants.

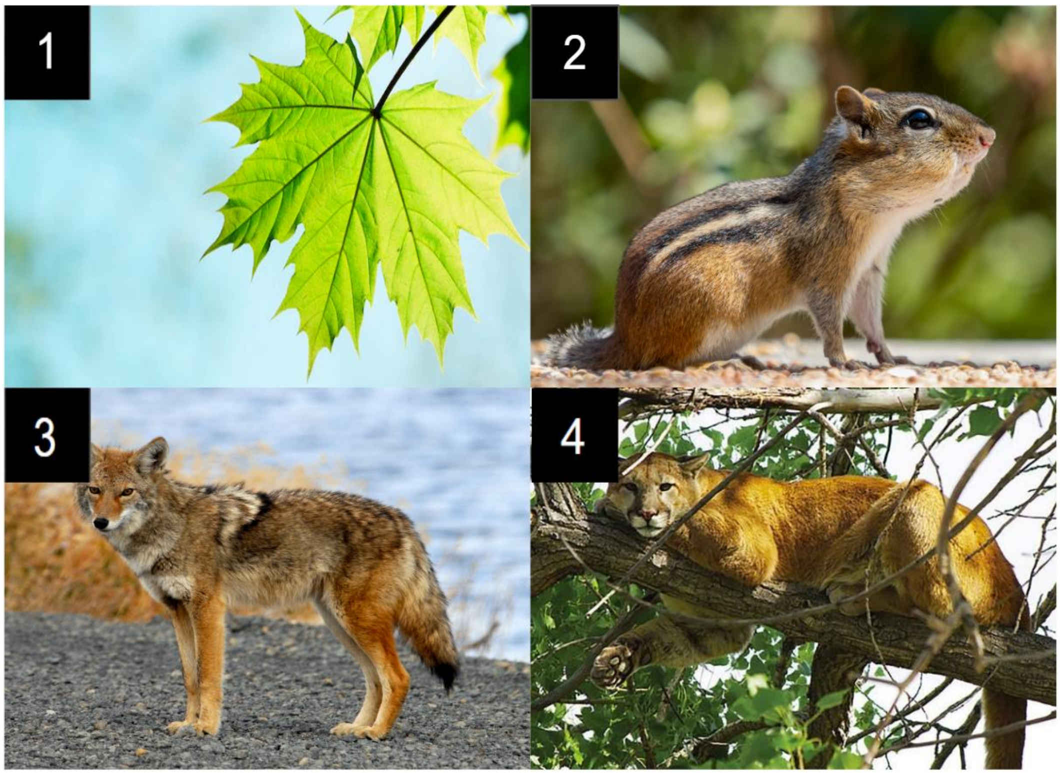
Figure A5. Stimuli for Training Trial

Note. This figure displays the photographs used in the training trial food chain. The number listed in the top right of each photograph shows the correct food chain sequencing. These numbers are not provided on the photograph given to the participants.

Figure A6. Stimuli for Food Chain A

Note. This figure displays the photographs used in Food Chain A. The number listed in the top right of each photograph shows the correct food chain sequencing. These numbers are not provided on the photograph given to the participants.

Figure A7. Stimuli for Food Chain B



Note. This figure displays the photographs used in Food Chain B. The number listed in the top right of each photograph shows the correct food chain sequencing. These numbers are not provided on the photograph given to the participants.

Figure A8. Stimuli for Food Chain C

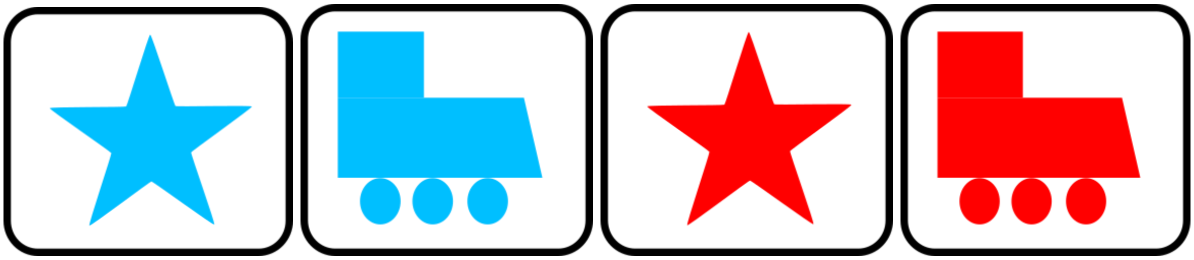
Note. This figure displays the photographs used in Food Chain C. The number listed in the top right of each photograph shows the correct food chain sequencing. These numbers are not provided on the photograph given to the participants.

Table A13. Correct Organism Order for Ecological Food Chains

Familiarization Trial: Carrot-Rabbit-Fox
Training Trial: Grass-Deer-Black Bear
Food Chain A: Grass-Mouse-Snake-Hawk
Food Chain B: Maple Tree Leaf-Chipmunk-Coyote-Cougar
Food Chain C: Oak Tree Acorn-Squirrel-Racoon-Mountain Lion

APPENDIX B: THE DIMENSIONAL CHANGE CARD SORT STIMULI

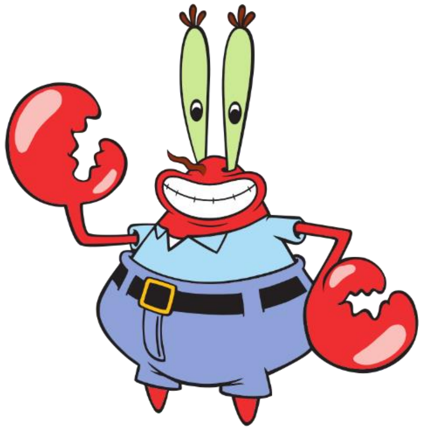
Figure B9. Stimuli for DCCS



Note. This figure shows the four different stimuli that are sorted on the Virtual DCCS (Doebel, 2020; Stucke et al. 2022; Stoet, 2010, 2017).

APPENDIX C: STIMULI FOR SERIAL ORDER TASK

Figure C10. Mr. Krabs

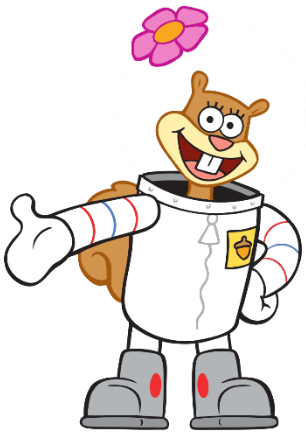


Note. This figure is Mr. Krabs, which is the first or "A" character in the serial order task.

Figure C11. Patrick

Note. This figure is Patrick, which is the second or "B" character in the serial order task.

Figure C12. Sandy

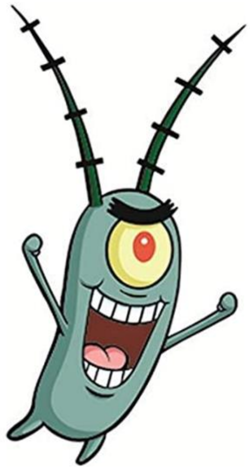


Note. This figure is Sandy, which is the third or "C" character in the serial order task.

Figure C13. Squidward

Note. This figure is Squidward, which is the fourth or "D" character in the serial order task.

Figure C14. Plankton



Note. This figure is Plankton, which is the fifth or “E” character in the serial order task.

Figure C15. SpongeBob

Note. This figure is SpongeBob, which is the reinforcement character in the serial order task.

APPENDIX D: REGION OF LIVING BY ZIPCODES

Table B14. Region of Living Defined by ZIP Code

ZIP code	Name	Population Density	County	Region of Living	Frequency
27006	Advance	222	Davie	Rural	5
27011	Boonville	103	Yadkin	Rural	1
27017	Dobson	89	Surry	Rural	2
27018	East Bend	93	Yadkin	Rural	1
27020	Hamptonville	87	Yadkin	Rural	2
27021	King	340	Stokes	Rural	6
27023	Lewisville	428	Forsyth	Rural	2
27040	Pfafftown	408	Forsyth	Rural	2
27055	Yadkinville	133	Yadkin	Rural	5
27103	Winston-Salem	1,789	Forsyth	Urban	2
27127	Winston-Salem	1,146	Forsyth	Urban	1
27282	Jamestown	1,151	Guilford	Urban	2
27284	Kernersville	640	Forsyth	Urban	1
27403	Greensboro	3,643	Guilford	Urban	4
27405	Greensboro	1,437	Guilford	Urban	6
27406	Greensboro	823	Guilford	Urban	1
27408	Greensboro	2,268	Guilford	Urban	5
27410	Greensboro	1,603	Guilford	Urban	19
27455	Greensboro	968	Guilford	Urban	3
27704	Durham	856	Durham	Urban	1

28373	Pinebluff	980	Moore	Urban	1
28621	Elkin	149	Surry	Rural	2
28627	Glade Valley	57	Alleghany	Rural	1
28635	Hays	93	Wilkes	Rural	1
28642	Jonesville	158	Yadkin	Rural	3
28654	Moravian Falls	56	Wilkes	Rural	1
28659	North Wilkesboro	207	Wilkes	Rural	3
28663	Piney Creek	35	Alleghany	Rural	1
28669	Roaring River	68	Wilkes	Rural	1
28670	Ronda	73	Wilkes	Rural	1
28675	Sparta	57	Alleghany	Rural	1
28676	State Road	122	Surry	Rural	3
28683	Thurmond	51	Surry	Rural	1
28697	Wilkesboro	204	Wilkes	Rural	1

Note. (U.S. Census Bureau, 2021; United States Postal Services & U.S. Census Bureau, 2022) North Carolina Appalachians counties: Alexander, Alleghany, Ashe, Avery, Buncombe, Burke, Caldwell, Catawba, Cherokee, Clay, Cleveland, Davie, Forsyth, Graham, Haywood, Henderson, Jackson, McDowell, Macon, Madison, Mitchell, Polk, Rutherford, Stokes, Surry, Swain, Transylvania, Watauga, Wilkes, Yadkin, and Yancey (Appalachian Regional Commission, 2021).