PARTITION DEPENDENCE IN DEVELOPMENT:
HOW GROUPINGS OF OPTIONS INFLUENCE
DECISION MAKING IN CHILDREN AND ADULTS

By
Sheri Reichelson
Faculty Advisor: Dr. Hilary Barth

A Dissertation submitted to the Faculty of Wesleyan University in partial fulfillment of the requirements for the degree of Master of Arts

Middletown, Connecticut May 2017
Acknowledgments

I must first and foremost attempt to give my thanks to my thesis advisor, Hilary Barth. I appreciate enormously the many hours she patiently spent guiding me with this thesis. Her mentorship was invaluable during this past year of thesis writing, but began much earlier on. As a sophomore student in her Developmental Psychology class, I began volunteering in her Cognitive Development Lab, not yet knowing that her mentorship would continue for the rest of my undergraduate career and, surprisingly, an extra year past that. I learned more than I could have imagined about critically thinking, designing, and writing in the discipline of psychology and beyond.

I also would not have been a part of this lab and thesis project if not for Jessica Taggart, the wonderful lab coordinator whom first welcomed me to the lab. Thank you also to Alexandra Zax, Andrea Patalano, and Ilona Bass for their co-authorship in the publications to come. Their ideas and feedback throughout these experiments were instrumental; thank you for the many meetings and discussions every step of the way. This project would not be the same if not for Andrea Patalano’s decision making guidance; thank you for jumping fully on board without knowing what lay in store. Thanks to Alexandra Zax for her time and patience with these statistical analyses, as well as for her patience with me. I am beyond grateful for her support as a lab coordinator and as a friend.

Thanks also to the staff at the Connecticut Science Center, and the many families who participated. I could not have collected this unbelievably large amount of data without the help of the research assistants in the Cognitive Development Lab.
and the Reasoning and Decision Making Lab. I thank them for bearing with me through the many variations of procedures and the multiple studies, though I cannot promise that the “PD” acronyms will stop yet.

A warm thank you to the Psychology Department and faculty at Wesleyan University for arousing my passion for psychology and providing me with the academic tools to accomplish this thesis. Faculty members whom I have had the pleasure of sharing a classroom or lab space with have an amazingly genuine enthusiasm for psychology and for their students at Wesleyan.

Thank you to my family for providing me with the opportunity to attend a university that I will always consider home. I send my love and gratitude to my amazing ladies of 260 Pine and to all of my support system at Wesleyan, especially to Brittany Curran, Rachel Eisman, Jen Farris, Ariel Kaluzhny, Jill Moraski, Margaux Sica, and Heidi Westerman. I do not believe that I could have completed this thesis without their encouragement and confidence in me, both during my undergraduate and graduate years. When I doubted if I would make it to April, they were there to keep me motivated and moving forward. I appreciate and love you all so very much.

This work benefited from a Stipend Award from the National Living Laboratory Initiative with funding from NSF under Award Number 1113648, a Wesleyan University Project Grant, NSF DRL-0950252, and NSF DRL-1561214.
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Abstract

The partitioning of options into arbitrary categories has been shown to influence adults’ decisions when making selections or allocations among those categories; this tendency is called “partition dependence” and is observed to occur across a variety of scenarios. In three selection experiments ($N = 299$) I asked whether a candy selection task elicits partition dependence in children and adults as reported in a previous adult study (Fox, Ratner, & Lieb, 2005). The physical partitioning of candy across bowls did not influence the selections of adults or children in the task, conflicting with previous findings. In three allocation experiments ($N = 159$ children and a preliminary $N = 60$ adults) I tested to see if children and adults exhibit partition dependence in a novel resource allocation task. This novel task of distributing food tokens to zoo animals elicited partition dependence in older children and younger children, with younger children exhibiting a stronger degree of partition dependence. Preliminary adult results suggest that the physical allocation task does not influence adults’ decisions. This thesis questions the scope of partition dependence in physical choices and proposes explanations for the discrepancy between these selection findings and previous selection findings. Importantly, this thesis provides the first evidence of partition dependence in children, suggesting that younger children are more susceptible to partition dependence and laying the groundwork for future developmental investigations into the phenomenon.
Introduction

Decisions and judgments are influenced by a variety of biases, heuristics, and factors, some of which lead to less rational decision making. One of the influences on decision making is the phenomenon "partition dependence," referring to the effect option arrangement has on decisions (Fox et al., 2005). Partition dependence occurs as a consequence of reliance on diversification bias, a type of maximum entropy heuristic that causes people to vary their choices among available options (Fox, Bardolet, & Lieb, 2005). Research on partition dependence has been limited to adults, but several studies provide reason to hypothesize that partition dependence may also exist in children. This literature review will explore these topics in depth and provide motivation for the thesis experiments that follow.

Decision Making

Decision making and judgment are being studied through the lens of multiple models that debate the extent of rationality and logic in people’s behavior. Some models argue that people make decisions that are perfectly rational, leading to choices that maximize positive outcomes (e.g. economic or perfect rationality model; Güth & Kliemt, 2004). Other models, in contrast, insist that people do try to act rationally, but are bounded by cognitive limits (e.g. Simon’s bounded rationality model; Munier et al., 1999). Psychological research supports these latter models, arguing that people’s decisions are more complicated than perfect rationality.
A few decision making researchers suggested that there are two types of processes responsible for making our imperfect decisions (Kahneman, 2011). The first, system 1, is a system for making fast, intuitive choices and the second, system 2, is a system for making slower, deliberate choices. Most of our choices are made by our automatic system 1, which conserves cognitive energy by relying on involuntary, effortless impressions and associations to make decisions. These automatic decisions are frequently reliant on heuristics. Heuristics are mental shortcuts or processes that aid people in making quick judgments (Tversky & Kahneman, 1974). However, automatic decisions based on heuristics are more prone to biases that can lead to inaccuracy.

These inaccuracies are relevant to the understanding of economic choice, specifically in the models of expected utility theory and prospect theory (Kahneman & Tversky, 1979). Both theories are used to describe how a person comes to a decision under uncertain circumstances such as betting in a lottery. Prospect theory, in contrast to expected utility theory, acknowledges that real-world evaluated value is influenced by subjective feelings and psychological biases, not just by objective value. Both the prospect theory on choice and the two-system decision making model work on the assumptions that people make biased decisions that are not always founded in logic. Some of these biased decisions lead to erroneous choices that are not in the interest of the decision-maker and other involved parties.

Many people, however, are unaware of the biases in their own decisions. The automatic system, prone to biases and reliant on heuristics, acts without effort or
consciousness, so these intuitive biases usually remain unnoticed. Yet, the average citizens, the investment brokers, and the CEOs of society pride themselves on their ability to make logical, maximizing decisions.

In actuality, when people make decisions, they are affected by a variety of factors; these factors change the way people think about and pick their choices, much of the time due to overreliance on our automatic system. A large area of psychology and marketing is researching the influence certain factors have on our decision making. Depending on the context, these factors impact people’s decisions either for the better or for the worse.

Influences on Decision Making

I review factors that influence decisions and judgments through three categories, which I define: environmental (external) factors, personal (internal) factors, and decision design (set-up) factors. One type of influence on decision making is an environmental factor; these factors are external to the decision or question. For example, people are more likely to conform to the decisions of others when the room temperature is warm (Huang, Zhang, Hui, & Wyer, 2014). Visuals like window displays, floor merchandising, and promotional signage increase consumers’ impulse purchases (Mehta & Chugan, 2013). The presence of peers increases impulsive purchasing while the presence of family members decreases it (Luo, 2005). These external factors involuntarily affect people’s decisions.
Personal factors such as mood also involuntarily affect the decisions people make (Laborde & Raab, 2013). People make different ethical and moral judgments depending on whether they are primed with positive, negative, or neutral mood states (Guzak, 2015). Additionally, when people are triggered to think about their preferences or already have strong preferences, they more strongly weight their preference in their decision making process (Fox et al., 2005). People’s decisions and judgments are also affected by systematic errors called cognitive biases (Tversky & Kahneman, 1974). Cognitive biases can cause people to do things such as overlook important information to confirm their own beliefs (confirmation bias) or to feel like they knew an answer from the start (hindsight bias) among other existing biases (Montibeller & von Winterfeldt, 2015). Heuristics also lead to biases (Tversky & Kahneman, 1974). As mentioned earlier, our automatic decision system is especially prone to cognitive biases and heuristics. For example, events that people can easily recall are overestimated in probability due to the availability heuristic; this can lead people to make irrational judgments about the likelihood of an uncommon event like a plane crash or a shark attack (Montibeller & von Winterfeldt, 2015). Past experiences, which occur on an individual basis, influence the future decisions a person makes (Juliussen, Karlsson, & Garling, 2005). In some instances, people consider past losses and gains when making later decisions (Juliussen et al., 2005). Along with internal factors are individual differences that affect how people make decisions; age, personality, and established beliefs all affect the decisions that people
Outside of these environmental and personal impacts on decisions, there is the third influencing factor – decision design, or the set-up of the decision. The decision design includes the structure, context, and elements directly relating to the decision. These factors can be physical like how clothing items are grouped in a store or they can by verbal like the phrasing of a sale. Additionally, these factors can be intentional on the part of the choice architect (making an expensive object front and center) or can be unintentional with an inadvertent effect. These decision design factors can nudge even the deliberate decisions that a person makes. “Nudging,” in the context of judgment and decision making, is defined as subtly influencing people’s choices without eliminating options or significantly making some options seem less preferable (Hausman & Welch, 2010).

These nudges can occur in two ways: in the structure of the decision task and in the structure of the decision options. If the decision task, for example, is set up with a default option, then choices are guided by this default (Johnson et al., 2012); we are biased towards choosing the option that requires less cognitive effort. Imagine you are prompted to enter your email on a website for a $10 coupon. When you enter your email address, you receive the message, “You are now subscribed to the weekly Decision-makers Newsletter. If you’d like to adjust your subscription, click below.” The default option is to remain subscribed; this default nudges you to stay on the listserv. The way a decision is framed can also push people towards choosing a
certain option by playing upon heuristics and biases; when decisions are framed as possible losses instead of possible gains, people may be more likely to take action – “Do you want to lose out on a free $10 towards your purchase?” vs. “Receive $10 off of your purchase!” (Montibeller & von Winterfeldt, 2015). The former sentence is more likely to sway people.

Decision options also guide people’s choices. Having too many or too few options can affect a person’s behavior; too few options and a person may decide they don’t like any of the options, too many options and a person may be cognitively overloaded (Johnson et al., 2012). Additionally, when three choices are presented, people tend to exhibit a “compromise effect” and choose the middle-most option (Kamenica, 2008). In one study, participants chose which brand of mouthwash they would likely purchase (Simonson, 1989); participants tended to compromise between the two more extreme options by choosing the option with the most moderate qualities.

A final example of a decision option effect, and the focus of the present research, is a phenomenon called partition dependence. Partition dependence is when decisions or judgments are affected by the groupings of options and possibilities (Fox et al., 2005). These groupings are called “partitions.” The partitioning of options can influence consumer choices, resource distribution, and judgments, even when partitions are completely arbitrary or subjective. Partition dependence has been shown in a wide range of contexts, and has been extensively
demonstrated in situations where people choose a multitude of items from an array of options.

To demonstrate this effect, picture yourself in a grocery store, choosing six meals from the frozen food aisle. The frozen meals available are ginger stir-fry, lemon chicken, spaghetti, pork chop, sesame noodles, and beef burrito. The grocery store has the six meals divided on the shelves by “lean meals” and “regular meals.” On the shelf of lean meals, there are the ginger stir-fry and lemon chicken meals; on the shelf of regular meals, there are the spaghetti, pork chop, sesame noodles, and beef burrito meals. You decide to purchase three of the lean meals (two stir-fry entrees and one chicken entree) and three of the regular meals (spaghetti, pork chop, and noodles, forgoing the burrito). The next time you go to the same grocery store, you see that the same frozen meals have been rearranged by “vegetarian meals” (spaghetti, ginger stir-fry, and sesame noodles) and “meat meals” (lemon chicken, beef burrito, pork chop). You decide to buy three vegetarian meals and three meat meals. The partitioning of meals into different groups nudges you to divide your choices among the presented categories.

This example of partition dependence occurs in part because of a cognitive bias called diversification bias: the tendency to seek variety when choosing goods or making decisions (Read & Loewenstein, 1995). Rather than selecting several of the same frozen entrée, customers in these situations tend to distribute their choices among the options (Simonson, 1990). People tend to diversify not just over individual options, but also over groupings of options, such as lean and regular meals. The
groupings of options do not have to be externally defined categories; they can also be subjective categories that a person mentally imposes on items. A person can just think of the frozen meals as vegetarian vs. meat. Diversification across groupings or partitions of options can consequently lead to partition dependence: the grouping of the options shapes a person’s behavior.

Evidence of Diversification Bias

Diversification bias occurs in a wide range of situations. People tend to diversify their choices across different financial investments (Benartzi & Thaler, 2001), across music choices (Read, Antonides, Ouden, & Trienekens, 2001), and across yogurt flavors (Simonson & Winer, 1992). This diversification happens most consistently when people are choosing multiple things at once for future time periods (Simonson, 1990).

One of the first studies looking at diversification bias was by Simonson (1990), where three groups of participants were asked to select three snacks to consume at the end of specific class sessions. One group (simultaneous-immediate group) was questioned once, choosing all three snacks simultaneously and immediately receiving all three snacks. The other two groups instead had their snacks spread out over class sessions for the next three weeks, one snack per week. Of these two groups, one group (simultaneous-delayed group) was questioned once and simultaneously chose all three of their snacks for the three future weeks. The other group (sequential-delayed group) was questioned once each week to choose the snack
they wanted to consume that class session (i.e. they were asked each of the three weeks for their weekly snack choice). Both groups that chose snacks simultaneously chose more variety than the group that chose sequentially. Participants in the sequential-delayed group were much more likely to choose their preferred snack each time they were questioned. Another study showed that when more items are purchased at once, people choose a greater variety of items (Simonson & Winer, 1992).

Diversification occurs most often in situations where people are acting naïvely using minimal information, leading to naïve diversification (Benartzi & Thaler, 2001). When people are uncertain about the prospects of options, they may try to minimize the risk by diversifying their choices among the options. People tend to use naïve diversification when choosing investment options for savings portfolios, diversifying their portfolio selections among the investment options offered. Naïve diversification often results in the use of the “1/n heuristic”, where n is the number of perceived variables or target options (Benartzi & Thaler, 2001). People evenly divide up available resources among the n options present.

Naïve diversification and the 1/n heuristic do not as neatly explain other diversification tasks involving consumer choice, such as the previously mentioned snack study (Simonson, 1990). Naïveté is not directly relevant to choosing similarly appealing snacks, nor would a 1/n heuristic explain the difference in variety chosen between the simultaneous and sequential groups. One theorized reason for this kind of consumer diversification bias is time contraction (Read & Loewenstein, 1995).
Time contraction suggests that people mentally contract future time during their decision making process, which causes them to overestimate how satiated they will be with one item in the future. People choose a variety of items to combat this predicted satiation; they want to avoid still having two frozen stir-fry meals when they become tired of stir-fry after eating the first one.

Two studies link time contraction to diversification bias (Read & Loewenstein, 1995). In one study, participants were asked to make either hypothetical or real choices about the snacks they would like to consume over the next days and weeks. Some participants were told to imagine that they were going to consume one snack per day for the next three days and then were told to choose the three snacks. The same participants were then told to imagine they were going to consume one snack per week for the next three weeks; they again chose three new snacks. A second study with a new set of participants did this task in the reverse order, with participants completing the week condition first and the day condition second, choosing two sets of three snacks each. Participants who went from the day to week condition, as hypothesized, expanded instead of contracted time; weeks seem further apart after considering the closeness of days. These participants, primed with time expansion, were less likely to predict item satiation and displayed less diversification bias in their second scenario. Participants in the week to day condition did not show a difference in their variety seeking since, as predicted, time became even more contracted when switching to the “day” prompt.
There are specific circumstances under which diversification is more or less likely to occur. Choice bracketing, meaning the timing and grouping of decisions, can influence the likelihood that decision makers will exhibit diversification bias and, consequently, exhibit partition dependence (Read & Loewenstein, 1995). For example, people can be asked to choose two candy bars in multiple methods; the choice of two candy bars can be separated so that each candy decision is independent, or the choice of two candy bars can be grouped so that they are thought of as one decision task. In other words, the two candy bar selections can be bracketed independently or bracketed together. When choices are bracketed together, people are more likely to demonstrate diversification bias. In one experiment, children were assigned to one of two conditions. In one condition, children visited two houses and were told to choose one candy at each house; in the other condition, children visited one house were asked to choose two candieds at that house (Read & Loewenstein, 1995). Children who chose two candies at once (decisions bracketed together) selected a greater variety than children who chose one candy at two separate locations (decisions bracketed separately). The bracketed, simultaneous choice prompted diversification bias in the participants.

Simultaneous choices, naïveté, and time contraction can lead to biased decisions, some of which are less favorable than unbiased decisions. When participants chose songs for a playlist at the same time or made simultaneous gambling choices, participants were less pleased with their choices (Read et al., 2001). Diversification bias can nudge a person to make decisions against one's own
interests and desires. However, diversification bias can also be used to push people towards better and healthier decisions. Additionally, choice partitioning can affect decisions for the better or the worse, both intentionally and unintentionally due to diversification bias. There are several tendencies analogous to diversification bias that can prompt biased decisions and partition dependence. These tendencies, including diversification bias, are regarded as maximum entropy heuristics (Fox, Bardolet, & Lieb, 2005).

**Maximum Entropy**

People tend to be partition dependent and to diversify when they divide their limited number of selections over the existing options. In different situations, people divide up scarce resources other than consumer selections; they may divide up a limited number of choices (raffle tickets), money (investments), probability (weather judgments), and preference (personality characteristics) over the target items. When people make these decisions, they rely on strategies that evoke *maximum entropy* (Fox, Bardolet, & Lieb, 2005). The term entropy, generally meaning uncertainty, here means uncertainty of outcomes (Giorgi & Mahmoud, 2016). Maximum entropy means that there is maximum uncertainty or maximum ignorance and hence all outcomes have equal probability of occurring. In situations of maximum entropy, the scarce resource is evenly distributed among the target items due to the equal probability. The more strongly people demonstrate partition dependence, distributing
evenly among the target groups, then the more strongly people are relying on maximum entropy heuristics.

People’s decisions often appear to be determined by a combination of reliance on maximum entropy heuristics and partitions and reliance on existing beliefs and preferences. If some information is available, people may first mentally divide resources equally and then adjust the distributions by incorporating information; this is known as anchoring and adjusting (Tversky & Kahneman, 1974). When ignorance is not at its maximum (due to available information, preferences, or beliefs), entropy will also not be at its maximum; allocation of resources will then deviate away from an equal distribution.

Fox, Bardolet, & Lieb (2005) presented several heuristics analogous to diversification bias that occur in different situations, a few of which I list here. As stated earlier, when people divide their selections among consumer options, they seek variety, diversifying their choices among the options. Similarly, in situations when people are dividing money among uncertain investment prospects, people rely on the maximum entropy heuristic of naïve diversification, distributing their capital evenly among the options. Yet, when people allocate resources to third-parties, they rely on an equality heuristic, dividing resources equally between recipients. People rely on the principle of insufficient reason when judging uncertain probabilities of events, weighting each perceived outcome as equally possible due to lack of better information. As in naïve diversification tasks, in other maximum entropy situations the likelihood of the scarce resource being distributed to a certain target is “1/n,” with
$n$ again being the number of perceived targets. The $1/n$ fraction is also known as the *ignorance prior* (See et al., 2006). An ignorance prior is a probability fraction people use by default when they have no information about outcome likelihoods (e.g. in situations of maximum entropy). For example, if there were five possible outcomes, the ignorance prior would be $1/5$ and would assume that each outcome has a $1/5$ chance of occurring.

Maximum entropy heuristics can sometimes be helpful in minimizing error, but can also make a person vulnerable to decision making nudges. On the positive side, they can help a person act fairly in resource allocation tasks, avoid statistical error in possibility judgment tasks, and maximize future satisfaction in selection tasks (Fox & Clemen, 2005). When a person is operating with minimal information, this heuristic reliance can improve decision making. Additionally, reliance on maximum entropy heuristics can lead to unconscious nudges such as partition dependence. Marketers can intentionally use partitions to nudge the $n$ number of perceived options, thereby changing the likelihood of resources being distributed to certain options. By organizing frozen meals into lean and regular categories, grocery stores may sway a person’s purchases towards more expensive meals or towards healthier options. People also encounter partitions and maximum entropy heuristics in higher stress situations where errors in judgment can have significant consequences. When entering a new job, for example, people make multiple high stress decisions about retirement savings, healthcare insurance, and flexible spending. The partitioning of
retirement plan options may affect a person’s enrollment, and then can have lasting impacts on the decision-maker until late age.

**Varieties of Partition Dependence in Decision Making**

The arbitrary partitioning of options has emerged as one influence on decision making, observed across a range of different situations. It is necessary to take a deeper look at the existing observations of partition dependence to understand the phenomenon and determine where future research should aim. Evidence for partition dependence is emerging in a variety of scenarios: financial investments (Bardolet, Fox, & Lovallo, 2009), snack choices (Fox et al., 2005), gambling (Fox & Levav, 2004), and allocation of financial aid (Fox et al., 2005), among others. These experiments differ in crucial ways, which I explore through the literature: task domains, real versus hypothetical situations, single item vs. multi item choice, moderating factors, and participant populations.

**Task Domain.**

Partition dependence studies require participants to partake in a variety of tasks; I refer to the categories of these tasks as domains. Partition dependence studies generally fall among three domains of decision making: allocation, selection, and judgment. *Allocation* tasks require people to distribute resources among varied categories, groups or individuals. A person may be required to allocate financial resources among possible charities (Fox et al., 2005). *Selection* tasks require people
to select items or options for their individual consumption or possession. People may decide which hotel they favor from a list of hotels (Martin & Norton, 2009). Lastly, *judgment* tasks require people to evaluate the likelihood or possibility of a specific outcome. People could judge the likelihood that Sunday would be the hottest day of the week (Fox & Rottenstreich, 2003).

**Allocation.** When allocating resources to groups, norms such as equality, equity, merit, effort, ability and need norms affect people’s allocations (Fox et al., 2005). In study settings, certain norms are more salient than others; for example, if a task emphasizes the disparate need of groups, then a person may be less likely to distribute resources equally among the groups and more likely to distribute based on need. Allocation partition dependence studies can emphasize one or more of these distributive norms and see whether setting up partitions affects people’s choices. In one study, participants were asked to allocate financial aid resources across six different income ranges (Fox et al., 2005). In a low-income condition, the six income groups ranged from less than $15,000 to more than $75,000; in a high-income condition, the six income groups ranged from less than $75,000 to more than $145,000. Adults allocated more financial aid resources to the lower-income bracket when the lower end of the income range was arbitrarily partitioned into more categories (the low-income condition), even when those categories were explicitly described as arbitrary. Study participants did try to allocate based on need by giving more financial aid to the lowest income partitions, however data were partition dependent; participants based need determinations on the partitions of the income
groups. For example, in the low income partition, participants distributed 95.9% of the aid to income brackets less than or equal to $75,000; however in the high income partition, participants only disturbed 47.7% of the aid to income brackets less than or equal to $75,000.

Additionally, when participants are asked to allocate donations to charities, the partitioning of the charities affects participants’ division of resources (Fox et al., 2005). One study was designed to see if having participants donate in separate stages (hierarchical or non-hierarchical) would change the amount they donated to domestic vs. international charities. Participants in the nonhierarchical condition were told to donate among five choices (international funds, domestic senior funds, domestic youth funds, domestic health funds, and domestic family funds). Participants in the hierarchical condition were told first to allocate money between international and domestic funds; then, participants were instructed to take the money they allocated to the domestic funds and further divide that money among the four domestic programs (seniors, youths, health, and families). Participants in the hierarchical condition were aware of all of these categories before allocating the resources. If people show partition dependence, then they would evenly diversify allocations among the categories presented at each stage (in the nonhierarchical condition diversifying across five categories, while in the hierarchical condition diversifying across the first two). Results showed that participants were significantly affected by the partitions, allocating an average of 55% of resources to international charities in the hierarchical condition, but only 21% to international charities in the nonhierarchical condition.
Fair allocation of resources to different groups, people, and sections is crucial for the functioning of society, and for the success of recipient groups. Government branches, for example, must decide how to allocate budgets to different departments; relying upon partitions alone can result in underfunding for suffering programs and overfunding for well-developed programs. Allocation can also occur on a more personal level and have large impacts for people’s social relationships. A person can conceptualize allocating time to family vs. friends or to family vs. friends vs. significant other. A person may spend more or less time with certain people depending on how they mentally partition their social relationships.

**Selection.** A large area of partition dependence research looks at people’s selections and choices. In one study, graduate students were recruited and told that three free campus meals would be randomly given out to the participants in the study (Fox et al., 2005). Participants were told to choose when they would like to schedule their three free meals if they were one of the random winners. The study had three conditions to determine whether partitions of options (in this case, the partition of time periods) would affect participants’ choices. All conditions were based on the academic calendar in which there are the Fall and Spring semesters each comprised of two terms; Fall semester is comprised of term I and term II, and Spring semester is comprised of term III and term IV. In condition 1, participants were told to divide three free meals among term I, term II, and Spring semester. In condition 2, participants were told to divide their meals between the Fall semester and the Spring semester. In condition 3, participants were told to divide their meals among Fall
semester, term III and term IV. Choices matched patterns predicted by partition dependence. Related research has shown that people choose to receive immediate rewards rather than delayed rewards; this study supported that finding with more meals selected for the Fall semester than the Spring semester in all three conditions (Fox et al., 2005). However, when the Spring semester was broken up into term III and IV, participants were four times as likely to select more meals for the Spring semester than when the Spring semester was left whole in the term I, term II, Spring condition. The partition effect was strong enough to alter the preference for immediate rewards.

Selection studies demonstrate that partitions can cause a person to rely less on their preferences and make decisions against their best interests. While evidence shows that partitions can affect more trivial decisions such as dining hall meals, partitions may also affect decisions with greater financial repercussions like which new car to purchase or how to mortgage a house. Even seemingly trivial selection tasks such as choosing a meal at a restaurant can have longer impacts on a person’s health over time. Similarly, selecting a house, a hometown, or a type of commute to work can have drastic impacts on a person’s happiness.

Judgment. People are also affected by partitions when making decisions or judgments based on probabilities. When people are asked to judge the probability of an event such as weather, they tend to bias their judgments towards the ignorance prior (Fox & Clemen, 2005). As previously stated, people use ignorance priors in
situations of high uncertainty. Partitions can affect people’s use of ignorance priors and nudge people to see outcomes as more or less likely to occur.

In one experiment, partition wording was used to prime different probabilities of the same event (Fox & Rottenstreich, 2003). Participants were asked the probability of Sunday being the hottest day of the week with two different wordings. One set of participants read “the temperature on Sunday will be higher than every other day next week;” this wording primes a two-fold partition of Sunday being hottest or Sunday not being hottest, creating an ignorance prior of $\frac{1}{2}$. The other set of participants read “next week, the highest temperature of the week will occur on Sunday;” this wording primes a seven-fold partition of each day of the week possibly being the hottest day (Sunday being the hottest, Monday being the hottest, Tuesday being the hottest, etc.). When priming a partition of $\frac{1}{2}$ (Sunday vs. not Sunday), participants’ judgments of the probability of Sunday being the hottest day of the week were closer to $\frac{1}{2}$ and when priming a partition of $\frac{1}{7}$ (Sunday vs. Monday vs. Tuesday, etc.), judgments were closer to $\frac{1}{7}$. The partition wording changed people’s probability judgments.

Similarly, when grouping outcome options, participants’ judgments are affected by the groupings. In a judgment study, participants were asked to predict the likelihood of several different schools being ranked #1 in a magazine survey (Fox & Clemen, 2005). They were told that Wharton school was ranked #1 the previous year. There were three conditions, with participants in each condition seeing a different partition of the outcomes, specifically the partition of Wharton vs. non-Wharton
schools. In condition 1, all schools were listed separately; participants were asked to judge the likelihood of the following schools being ranked #1: a) Chicago, b) Harvard, c) Kellogg, d) Stanford, e) Wharton, and f) None of the above. In condition 2, the non-Wharton schools were collapsed into one outcome; participants were instead asked to judge the likelihood of a) Chicago, Harvard, Kellogg, Stanford, or another school other than Wharton being ranked #1 and b) Wharton being ranked #1. In condition 3, non-Wharton schools were collapsed and non-specific; participants were asked to judge the likelihood of a) A school other than Wharton being ranked #1 and b) Wharton being ranked #1. Condition 1 created an ignorance prior of 5/6 for schools other than Wharton being #1 and Conditions 2 and 3 created an ignorance prior of ½ for schools other than Wharton. Results were consistent with partition dependence, showing that people estimated a greater probability of a school other than Wharton being #1 in condition 1 where each school was partitioned separately in comparison to when only two partitions existed in conditions 2 and 3.

Partitioned options and partitioned wordings have the ability to influence people’s perceived probability of outcomes in important situations. People consider probabilities in a variety of life situations from gambling to making medical decisions. A doctor priming a partition of survival rate vs. fatality rate will receive more optimism than a doctor priming a partition of survival rate vs. immediate fatality rate vs. delayed fatality rate; this optimism can then affect a patient’s decisions or affect the hospital’s treatment of the patient. Partitions can nudge people’s perceptions of probability in situations with extreme costs.
Real-World Application

Most experimental partition dependence studies look at the decisions of participants by asking participants to state their preferred course of action. These “hypothetical” studies ask which actions and answers participants would give, if the situation were real. “Hypothetical” studies stand in contrast to both “real” and “real-world” situations. “Real” situations have participants make actual decisions, but in the context of an experimental setting; “real-world” situations, however, refer to decisions made outside the context of a lab and therefore directly pertain to actual life decisions (Kühberger, Schulte-Mecklenbeck, & Perner, 2002).

For hypothetical contexts, participants’ stated preferences might differ from their actual preferences due to the existence of a hypothetical bias (Beck, Fifer, & Rose, 2016). Hypothetical biases are the discrepancies that occur between stated and actual behaviors partially due to incorrect self-evaluations by participants in hypothetical experiments. This leads to the potential for a lack of external validity for experiments with hypothetical decisions. There are a few ways to minimize the hypothetical bias; the most relevant method is providing an incentive for participants to care more deeply about their stated choices. One way to possibly do this is by saying that some participants’ choices will actually be binding or that some participants will receive their preferences if they win a raffle. Other evidence suggests that offering hypothetical rewards and large hypothetical incentives are enough to
dissipate the hypothetical bias (Johnson & Bickel, 2002; Kühberger, Schulte-
Mecklenbeck, & Perner, 2002).

Select partition dependence experiments used methods to increase external
validity. For example, some studies inform participants that a select few individuals
will be rewarded for their responses. One study rewarded participants with $1 if they
correctly guessed the outcome of a card game (Fox & Levav, 2004). Another task that
was previously mentioned had people choose the distribution of hypothetical free
meals; participants were informed that a few individuals would actually receive the
free meals as they indicated (Fox et al., 2005). Possible rewards create real
implications for participants, increasing the generalizability to the real-world.
Participants are making choices while aware that their decisions have an impact,
putting pressure on the participant to make a thoughtful choice.

**Anti-Diversifying & Single-item Choice**

The bulk of the research in this field and the majority of the experiments
discussed in this thesis are based in situations where people employ maximum
entropy heuristics in multi-item choice tasks. That is, people are making multiple
choices from the target items, and they do so by spreading out resources among the
options. In these settings, people’s multi-item selections demonstrate partition
dependence.

However, evidence of partition dependence has recently been found in
settings of single-item choice and is hypothesized to occur alongside anti-
diversification (Fox et al., 2005; Tannenbaum et al., 2015; Tannenbaum, Fox, & Goldstein, working paper). In single-item choice settings, people only have a single resource to distribute (e.g. choosing only one candy, distributing only one prize, or casting only one vote) as opposed to multiple selections or allocations. In one study, people’s single selections in a public opinion poll were affected by the partitioning of poll answers (Yamada & Kim, 2016). Participants were presented with a polling question asking whether they supported approving or disapproving the collective self-defense policy (CSD). In one condition, participants were shown two approve options and one disapprove option (“Approve the exercise of the right to CSD through constitutional revision”, “Approve the exercise of the right to CSD through changing the government’s interpretation of the constitution”, and “Maintain the position of disapproving the exercise of the right to CSD”) and in another condition participants were shown only one approve option and one disapprove option. The participants who received the poll with two “approve” options significantly more often chose to approve the CSD policy in comparison to those who saw only one “approve” option, suggesting an effect of partition dependence. In another study, physicians each made single choices as towards the treatment options for a hypothetical patient (Tannenbaum et al., 2015); the partitioning of the treatment options influenced the single-item choices. In a third study, participants made single-item decisions among partitioned categories of consumer options (Tannenbaum et al., working paper). For example, in one part of the task, adults chose a single movie from a list that either partitioned romantic comedy movies onto each of their own lines and collapsed
science fiction moves onto the same line, or a list with the reverse set-up (science fiction movies listed individually and romantic comedies collapsed). Choices were partition dependent, with more items being chosen from the categories whose items were partitioned into their own lines in comparison to those collapsed into a packed, one-line category. Researchers in that study claim that a mechanism different from diversification must be responsible for partition dependence in single-item choice situations. They assert that partitions communicate payoff-relevant information and that this information biases people’s decisions towards items partitioned individually.

I argue that partition dependence in single-item choice tasks can be a result of maximum entropy heuristics. Mental weight and probability can still be distributed to each option even when there is only a single resource to be allotted. For the public policy task, a person placed in the approve-approve-disapprove condition may mentally think that there is a 33% likelihood of choosing each option by naïvely distributing the probability. In the approve-disapprove condition, however, a person may see each option as having a 50% chance of being chosen by them. If this is the case, then maximum entropy heuristics are being used to calculate each option’s chance of being chosen.

A few accounts also speak of partition dependence during anti-diversification, meaning that a person purposely selects all of one item. One scenario described anti-diversification in terms of a family member buying gifts for three siblings (Fox et al., 2005). Imagine that a relative wants to purchase the same gift type for all three children to avoid disgruntlement. When educational toys and non-educational toys
divide the toy store, the relative might decide to purchase three different types of educational toys; however, if the toy store is instead divided by electronic toys and non-electronic toys, the relative might decide to purchase three electronic toys. This situation has been used as proof of anti-diversification partition dependence. While I do not assert that anti-diversification cannot lead to partition dependence, I do argue that this specific situation could also be thought of as involving single-item choice behavior. The family relative is approaching the situation knowing that they want all of the same toy type; they decide to choose one of the partition categories from which to make their three selections. These situations of anti-diversification and single-item choice are important for the implications for partition dependence outside of a lab setting.

**Moderators and Other Factors**

As with other psychological phenomena and biases, partition dependence is moderated and affected by several factors, a few of which I list here.

**Preference.** Preference for items and choices influences the effect of partitions on people’s decisions (Fox et al., 2005). When participants are asked their preference for an item before making a selection, the effect of partition dependence decreases. In a study that looks at preference, participants were tasked with choosing snacks for hypothetical consumption (Fox et al., 2005). Participants were asked their preference in snack options either before or after choosing. For those people that stated their preference first, there was no significant effect of the partitions on
choices. However, when participants stated their preference after the experiment, partition dependence was present. Stating preference prior to choosing was found to moderate the effect of partition dependence.

**Expertise and Knowledge.** When people are considered experts or educated about a topic, they are believed to be less susceptible to mistakes and ignorant decisions. A variety of studies demonstrate the inconsistencies in that claim. Partition dependence is moderated by expertise and knowledge, but not extinguished.

In one study, medical professionals read vignettes of patient symptoms and decided on a treatment plan for the patient (Tannenbaum et al., 2015). The possible treatment plans were partitioned into different groups to see if the way the treatment options were displayed affected medical professionals’ choices. One set of providers read a medical vignette and then were presented with aggressive treatments listed as separate options, while nonaggressive treatments were grouped together under a common heading. Another set of providers read a medical vignette and then was presented with aggressive treatments grouped together under a common heading, while nonaggressive treatments were listed as separate options. One of the conditions looked similar to the following set-up:

- ☐ Aggressive option 1
- ☐ Aggressive option 2
- ☐ Aggressive option 3

**Treatment heading:**

- ☐ Nonaggressive option 1  Nonaggressive option 2  Nonaggressive option 3
The health care providers were significantly influenced by the partitions; providers were more likely to choose the aggressive treatments when the aggressive treatment options were listed separately, but were more likely to choose nonaggressive treatments when the aggressive treatments were grouped under one heading.

When administering a partition dependence task with people trained in decision making analysis, participants still showed partition dependence, though the effect was weaker than with naïve populations (Fox & Clemen, 2005). Additionally, when comparing wine novices to wine experts in a selection task, wine choices of the whole sample were partition dependent, but partition dependence was weaker among the wine experts (Fox et al., 2005). Importantly, among the experts, partitions still play a role in the decisions made. In a field like health care, even minimal influences can have life changing effects.

Outside of expertise, knowledge and information is also introduced into partition dependence studies with a minimal or moderate effect depending on the situation. Partition dependence is more apparent in situations when the ignorance prior is strongly relied upon (Fox & Clemen, 2005). The ignorance prior (allocating $1/n$ resources to each target) is most strongly relied upon in uncertain situations when a person has minimal information at their disposal. Knowledge and information moderate the reliance on ignorance priors by decreasing uncertainty and providing participants with a reason to expect that each outcome does not have an equal chance of occurring. When participants had domain knowledge of their present task, they still
showed partition dependence in a judgment task. However, participants did show more partition dependence when they were naïve rather than knowledgeable (Fox & Clemen, 2005). For a task that provides information or evidence for participants to use in judging probabilities, there is a similar effect. When participants judge the likelihood of an event after being given information about the probabilities, participants’ strategies showed a combination of information evaluation and partition dependence (Fox & Levav, 2004). Their evaluations were less partition dependent than in an equivalent naïve situation.

**Category salience.** In some situations, partitions are based on similarities between items within the same partition (lean vs. regular meals); however, an item can belong to multiple groups or to none at all. Changing the category salience of an object can cause a person to mentally place objects in different groups. Category salience was observed to interact with partition dependence in a study that manipulated the group membership of an object, specifically the group salience of letters (Isaac & Brough, 2014). The study manipulated the group membership of the letters “A” and “T” by having them either be described as “letters” or described as members of their respective consonant/vowel group. For example, the letter “T” either belonged as an individual entity within the alphabet of 26 letters or belonged to the group of 21 consonants. Participants then judged the likelihood of “A” or “T” being rolled on a 26-unique-letter die (Isaac & Brough, 2014). Participants judged the likelihood of “T” being rolled as much higher than the actual probability when the consonant category was made salient over the general letter category. By
manipulating the group that objects belong to, it is possible to influence how likely or prevalent a person perceives an outcome or object.

Additionally, when categories or partitions are made increasingly salient, knowledge or expertise effects can be overridden. When participants in one study were tasked with observing frequencies of figures of varying shapes and colors in a computer screen, people more confident in their observations displayed less partition dependence (See, Fox, & Rottenstreich, 2006). However, this effect of confidence and information disappeared when the partition categories were made very salient.

**Demand Characteristics and Experimenter Effects.** One critique regarding partition dependence studies is that participants may be influenced by the experimental context and by the expectations of the experimenter. Participants may understand the purpose of the study (either through experimenter or experimental cues) and may be realizing that they should act based on the experimental partitions. Alternatively, participants may be attributing significance to the experimenter-determined partitions and drawing meaning from the groupings. Some studies attempt to show that experimenter effects and information extraction are not the cause of partition dependence and that partition effects occur independently of these experimental demands (Fox & Clemen, 2005). These studies introduce arbitrariness and motivation into experimental set-ups with the goal of isolating the partition dependence effect from other confounds.

One way experiments try to accomplish this goal is by conveying arbitrariness through experimental instructions. Written instructions or verbal instructions state to
participants that the experimental partitions are arbitrary, and thus participants should not draw meaning from the groupings. When participants are told that the given partitions are arbitrary (“these income categories were chosen arbitrarily”), participants’ choices are still influenced by the experimental partitions (Fox et al., 2005). However, it could be argued that stating the arbitrariness of categories is not enough to remove expectancy effects. In fact, drawing participants’ attention to the arbitrariness of partitions could possibly backfire and cause participants to focus more attention on the experimental set-up.

Another method to convey arbitrariness and disambiguate partition dependence is by conveying the randomness of the partitions through the experimental procedure. In one experiment, partitions were demonstrated to be even more arbitrary by having participants see two separate partition set-ups at the same time and randomly assign themselves to a specific condition (Fox & Clemen, 2005). Participants saw two partition setups with stock indexes. One setup had the indices partitioned as: below 1,000, 1,000-2,000, 2,001-4,000, and above 4,000. The other setup had these indices partitioned as: 4,000 or below, 4,001-8,000, 8,001-16,000, above 16,000. Participants were told if the last digit of their phone number was even then complete the partition on the left side of the page, and if the last digit was odd then complete the rightmost partition. Participants still showed partition dependence even with this demonstrated randomness of partitions. This study demonstrates that visual arbitrariness does not interfere with partition dependence. Participants’ choices are still guided by the partitions in even this self-assignment set-up.
A third way that studies disambiguate partition dependence is by giving participants additional motivation to make truthful and accurate decisions. Several create incentives for participants to combat expectancy effects and random responding. One method is telling participants that they are being entered into a raffle and some participants will receive the selections that they indicated in the experimental task (Tannenbaum et al., working paper). In allocation tasks, some participants were also told that random participants would be chosen and their allocations would be honored (Fox et al., 2005). In both of these studies, the arbitrary partitioning of options still influenced participants’ choices.

One issue with trying to separate the effect of partition dependence from the effect of information that experimental partitions convey is that partitions may also convey information in real-world settings (i.e. outside of a laboratory context). In this case, any information that partitions do convey would be more important to understand than to erase. If people walking around a grocery store aisle notice the groupings of cereal (e.g. sugar-free and not sugar-free) and draw conclusions based on those groupings, then information effects exist outside of an experimental setting. Information effects can exist both in an experimental setting and in real-world settings. Partitions would then significantly affect choices and judgments. In some settings, partitions may be conveying useful, normative information; however, in many situations partitions are incomplete and misinformative (Smithson, 2009).
Developmental Change and Special Populations.

Partition dependence, due to its nature as a cognitive phenomenon, may vary between different populations. Many aspects of cognition including memory, reasoning, and intelligence develop as people age from infants to older adults, as well as change due to life experiences (Saxe & de Kirby, 2014). However, most partition dependence studies have been conducted with college-aged students. A few studies looked at adults outside of the undergraduate-aged group, specifically due to their expertise or profession (Tannenbaum et al., 2015; Fox & Clemen, 2005). Some studies also used online Mechanical Turk to collect participant data, and consequently had mean ages above college age (Shah & Alter, 2014; Isaac & Brough, 2014; Tannenbaum et al., working paper). No partition dependence research to the author’s knowledge has been done with participants outside the college- to middle-aged group. This leaves out both older adults and children, leaving open the question of whether partition dependence undergoes a developmental change through the lifespan. One goal of this thesis project is to explore partition dependence in children. This last introductory section discusses research relevant to this goal.

Children and Decision Making

Children make many of their own decisions from a young age, deciding their after-school and in-school activities, their daily snacks, and what clothing to wear for the day. Partitions exist in these options, yet it is unknown whether partition dependence starts at an early age and is affected by development. Cognitive
development research explores the growth and change in thought processes from infancy to older adulthood, including in areas of social cognition, problem solving, and intelligence. Partition dependence and the tasks used in this thesis to test for partition dependence involve several aspects of cognitive development. In this section, I identify and explain how developmental factors pertain to partition dependence.

For partition dependence selection tasks, adults diversify their selections across the perceived categories. The possible developmental components of these selection tasks include perceiving categories from presented options and diversifying across these categories. There is some limited research on the existence of the diversification bias in children. In a previously mentioned study, children who were trick-or-treating were assigned to either choose two pieces of candy at one house or one piece of candy at each of two houses (Read & Loewenstein, 1995). Children who chose two pieces of candy at once tended to diversify across the candies rather than choose two of their favorite piece. The simultaneous situation demonstrated that children seek a variety much like adults; children show a diversification bias.

We also see that children have the skills needed in tasks where identifying partitions and categories is crucial. In one study, children were presented with toys that fell into different categories; their toy touching patterns were examined to see at which ages children categorize objects (Bornstein & Arterberry, 2010). Children as young as 12 months spontaneously categorized objects, with rates of categorization increasing into children three years of age (Bornstein & Arterberry, 2010). With age,
children improved in distinguishing between and categorizing increasingly similar stimuli (for example, first distinguishing a lion from a truck [animal vs. vehicle] and then a dog from a horse [animal breed vs. different animal breed]). Additionally, children categorize objects based on a range of characteristics, including perceptual categories such as color but also on less-perceptual levels such as function (Gelman & Meyer, 2011). Children as young as 13 months were able to use a verbal label to categorize two perceptually different items into the same category. For example, when learning a fact about a target bird, children were more likely to extend that function to a perceptually different bird (a dodo) than a perceptually similar bird (a pterodactyl) once these animals are labeled as “bird” and “dinosaur”, respectively.

Children as young as four years old can also think critically about a single item belonging to multiple categories (see Nguyen & Girgis, 2014, for review). A crucial part of children’s categorization skills involves language development, as evident from the previous study mentioned (Gelman & Meyer, 2011). For example, if children know the labels of certain objects, then they can categorize objects in a more advanced way. In the previously mentioned dodo/pterodactyl study, if children were not given the labels of “bird” and “dinosaur” and if they themselves did not already know these labels, then they would most likely rely on more perceptual features to determine how to categorize (extend properties onto) these animals.

Other lines of research give insight into the way children may behave in allocation partition dependence tasks. Adults in these tasks decide how to distribute resources among defined groups. For children, developmental considerations include
sharing habits, concepts of fair and equal, and mathematical division abilities. These considerations are also intertwined. For example, children’s fairness ability interacts with their sharing habits, and how correctly they distribute fairly can depend on their mathematics skills.

Children at a young age understand equality in item distribution. In looking tasks, infants as young as 12 months old prefer to look at equal distributions of objects as opposed to unequal distributions, suggesting a comprehension of equality (Geraci & Surian, 2011). Furthermore, children understand equal as fair. With third-party recipient groups, children show a strong preference for an equal division of resources (Shaw, DeScioli, & Olson, 2012). When children are presented with a “fair” person who equally gives two prizes to each of two kids and another “favoritism” person who gives all four prizes to one of the kids, 96% of children prefer the fair distributor who allocated the prizes equally (Shaw et al., 2012).

To my knowledge, these allocation studies with children have only been done in the context of allocating to agent recipients (persons). Many adult allocation studies, in contrast, involve allocating to non-agents (among stocks). It is possible that people may approach agent allocation tasks in a different manner than non-agent allocation tasks. Additionally, there may be developmental change associated with agent vs. non-agent allocation, with children approaching the tasks in different ways. Without information for or against this possibility, I work under the assumption that there is no difference associated with agency.
Young children also show a preference for selfish choices when they stand to benefit. In one study, children were able to choose how many sweets would be given to themselves and to an anonymous partner (Fehr, Bernhard, & Rockenbach, 2008). In one condition, a child could choose between giving one sweet to each, (one for herself and one for the anonymous partner) or could keep both of the two sweets for herself and give none to the anonymous partner. Three- and four-year-olds significantly exhibited non-sharing, selfish behavior with only 8.7% choosing to distribute the sweets 1 to 1. This selfish behavior decreased minimally for five- and six-year-olds, with only 22% sharing. For seven- and eight-year-olds, children significantly increased their sharing behavior, with 45% of children choosing to share the sweets equally. This unequal, “unfair” way of sharing in a first-party context can potentially also affect adults when they stand to benefit; partition dependence studies, possibly for this reason, focus on allocation in a third-party context.

Additionally, resource allocation tasks depend on children’s mathematics abilities. Many school math topics are taught with word problems involving sharing or distributing items. Children’s strategies in sharing problems depend on their mathematics skills. While children can recognize equal as fair and show a preference for fair distributions, they sometimes do not demonstrate fairness in their actual distributions, even in third-party contexts (Chernyak, Sandham, Harris, & Cordes, 2016). In an experiment with 2 ½ to 5 ½ year old children, older children were significantly more likely to distribute resources equally between two third-party recipients (Chernyak et al., 2016). These age differences were completely explained
by differences in children’s mathematics abilities, specifically cardinal principle knowledge. Cardinality refers to the number of items in a set; a set with five items has a cardinality of five (Gelman & Gallistel, 1978). When children become cardinal principle knowers, they can count to a specific number, understanding that the last number uttered corresponds to the number of items they counted. Before cardinal principal knowledge develops, children at young ages can begin to count to 10, but may not understand the meaning of “two” yet; rather they are memorizing a set of words without understanding how many items a number word corresponds to (Wynn, 1992). Around 3 ½ years old children became cardinal principle knowers (Carey, 2009; Le Corre, Van de Walle, Brannon, & Carey, 2006). They comprehend that a cardinal number is a property of a set that states how many items are in the set. When children were cardinal principle (CP) knowers, they were more likely to successfully distribute resources fairly (Chernyak et al., 2016). Additionally, the distribution strategy used by these CP and non-CP knowers differed. For those children that shared fairly, many children distributed resources in two key ways: by handing one resource out at a time to each receiver (turn-taking strategy) or by dividing the resources in half first and then giving each half to each of the receivers (division strategy). This turn-taking strategy is referred to in similar contexts as dealing (such as in a card game) and as distributive counting (Davis & Pitkethly, 1990). CP-knowers were more likely than non-CP knowers to use division instead of turn-taking when distributing the resources. Division is a more advanced skill that requires
greater mathematics knowledge than turn-taking. Additionally, turn-taking strategies can be more prone to error if a child forgets whose turn is next.

There is also reason to believe that kids rely on maximum entropy heuristics. The trick-or-treating study demonstrated the presence of diversification bias in children; children tended to equally allocate resources between third-parties (Read & Loewenstein, 1995). Additionally, maximum entropy heuristics occur most strongly in situations of uncertainty and minimal information. Children should approach decision making tasks with even less information than adults and therefore rely on these heuristics even more so.

However, children’s increased preferences provide one reason that children may not exhibit partition dependence. Children are known for having increased food pickiness and for exhibiting increased hatred for some types of foods (Dovey, Staples, Gibson, & Halford, 2008). Increased preference is associated with decreased levels of partition dependence. In realms such as food, where children have strong preferences, children’s decisions may rely less on partitions. Such a study has not yet been conducted.

To my knowledge, there have been no partition dependence studies with children. This may partly be due to the challenge of adapting a task for children; many partition dependence studies involve complicated content and instructions. Children lack the world knowledge and verbal skills to complete a classic partition dependence study. The present work adapts adult partition dependence paradigms for
use with children to determine whether children too show partition dependence in selection and resource allocation.
Experimental Investigations into Partition Dependence

Within the growing literature on partition dependence, there are still limited real tasks with non-hypothetical choosing. Developmental explorations of partition dependence also do not exist. My first goal was to replicate a physical study in adults and extend the task to children. My second goal was to further explore the possible existence of partition dependence in children.

Motivations.

The phenomenon of partition dependence has important implications for many types of decisions. For example, research on the justice system and juries has hypothesized that partition dependence and reliance on ignorance priors can have important implications for a juror’s standard of evidence and proof of guilt depending on how the case outcomes are partitioned (Bammer, 2010). Additionally, adults’ contributions to 401(k) plans are influenced by how the contribution plans are partitioned into different options (Beshears, Choi, Laibson, & Madrian, in press). Partition dependence can impact real-world adult decisions in these domain and others. For this reason, I set out to replicate one of the real partition dependence tasks to explore the mechanisms behind real-world partition dependence in adults.

Children are responsible for making many of their own decisions from a young age. Consequently, partitions are relevant to children. Parents might offer toddlers a choice between toys at a store, possibly partitioning the toy options by gender (e.g. “action figures”, “building blocks”, or “something else” for boys) or by
educational value (e.g. “stuffed animals” or “learning games”). Children also make extracurricular and school-related decisions, deciding on which clubs, sports, and classroom activities they want to partake in. Parents who heavily suggest their kids enter into a high-status profession may phrase career options as “doctor” or “everything else.” They are presented with school subjects in certain ways (“academics” vs. “arts” or “sciences” vs. “non-sciences” vs. “arts”), which can have impacts on the time they devote to each area. Children’s chosen activities, toys, and time devotion can impact later academic achievement, cognitive skills, and career interests. Even kids’ choices from partitioned food and active play can impact later health.

Aspects of children’s and preteens’ identities may also be affected by partitioning. Children and adolescents may be more likely to figure out their sexual identity depending on the categories they’re presented (“heterosexual” vs. “homosexual”, vs. “other”; “heterosexual” vs. “queer”; “heterosexual” vs. “bisexual” vs. “lesbian” vs. “gay”, vs. “transgender” vs. “queer”). A similar situation can apply to gender identity and binary categories of “woman/girl” and “man/boy.” Partitions are relevant to demographic identity aspects such as religion (“Christian” vs. “non-Christian”), ethnicity (“American” vs. “not American”), and race (“White” vs. “non-White”). Identity is linked to self-esteem and can have important consequences for later life outcomes (Stets & Burke, 2014).

These reasons led me to consider the existence of partition dependence in children.
Hypotheses.

Three main possible hypotheses exist. The first is that partition dependence may arise early in childhood; children’s choices, like adults’, may be influenced by the groupings of options, and their choices may demonstrate partition dependence. Children have the ability to recognize categories and tend to display maximum entropy heuristics, two important predicates to partition dependence. Children also have a tendency to equally allocate to third-parties. The second hypothesis is that partition dependence arises later and not in childhood; partition dependence may only emerge after long experience with making choices, or children’s choices may be more strongly determined by a factor like preference. Children’s still developing number skills, tendency towards self-serving allocation, and polarized preferences could contribute to this lack of effect. Alternatively, the third hypothesis is that children may be influenced by partitions, but in a different pattern than in adults; children may demonstrate a weaker reliance on partitions or may demonstrate the tendency in different task domains. This could occur because of a combination of the previous reasons.

Through six experiments, I explore the effect of partitions on adults’ and children’s decisions. In Experiments 1, 2, and 3, I explore partition dependence in selections tasks for both children and adults. In Experiments 4, 5, and 6, I shift gears to partition dependence in resource allocation, continuing the investigation into partition dependence patterns in children.
Partition Dependence in Selection Investigation

Most existing partition dependence tasks are not easily adapted for use with children. Many require complex cognitive skills and world knowledge. One of the exceptions is a real candy bowl task in which participants chose actual candies from partitioned bowls (Fox et al., 2005); it is well suited to child participants because the options, grouping, and decisions are visual and physical.

In the candy bowl task, a table is set up with three bowls containing four types of candy in total. Two of these bowls are each filled with a distinct type of candy; a third bowl is filled with the remaining two types of candy, each sitting in two distinct piles in one half of the bowl (figure 1). The three bowls create a three-way partition and the four candy types create a four-way partition. Researchers can then ask whether the partitioning of the four candies across the three bowls influences participants’ choices.

![Figure 1](image)

*Figure 1.* In the candy task, three bowls are displayed, each with unique candy types. One of the three bowls has two unique candy types. The dotted line represents the two separate piles of each candy.

Participants choose five candies from the set-up. Their choices were analyzed to see if their choosing patterns are consistent with partition dependence. If participants choose based on candy type alone (with no influence of the candies’
arrangement across the bowls), half the candies (2.5 candies) should be drawn from the two single-candy bowls combined, and half (2.5 candies) should be drawn from the double-candy bowl (figure 2). If, in contrast, people choose based on bowl distribution alone (with no influence of the candy types), two thirds of candies (3.33 candies) should be drawn from the two single-candy bowls combined, and one third of candies (1.67 candies) should be drawn from the double-candy bowl (figure 3).

In Fox et al. (2005), adult averages fell between these extremes, with more candy being chosen from the two single-candy bowls ($M = 3.01$) than the double-candy bowl ($M = 1.99$). This illustrated that choices of candy were not only driven by candy preference, but also influenced by the bowl partition.

![Figure 2. If participants chose based on candy types alone.](image)

![Figure 3. If participants chose based on partitions alone.](image)

To explore the existence of partition dependence in children, I adapted the
candy bowl task with small adjustments to the methods, which I will detail later. My first goal was to use the candy bowl task to replicate the original finding of partition dependence in adults. My second goal was to extend these results to children and test the existence of partition dependence in this age group. I am operating under the assumption that children (and adults) will choose a variety of the candies, relying on maximum entropy heuristics. In consumer choice and resource allocation tasks with multi-item choice, maximum entropy and diversification mediate the partition dependence effect. Partition dependence in these tasks operates by people diversifying among their perceived options. Assuming people diversify, I am exploring whether choices will also be partition dependent- that is, that people will diversify among the groupings of targets, not just the individual targets.

With most partition dependence tasks, participants are required to distribute or choose a specific number of items. A task will be completed in a different way if a participant does not know the number of items that they can choose or distribute. Understanding of number and cardinal principal knowledge develops over childhood, so children at younger ages will have little or no understanding of the meaning of some numbers. Children first learn the meaning of “one” usually between the ages of 2 and 2 ½ years of age, then they learn the meaning of “two” six to nine months later, followed by a few more months until they learn “three”, followed by “four,” until around age 3 ½ years when they became cardinal principle knowers (Carey, 2009; Le Corre et al., 2006). If children younger than 2 ½ years of age are tasked with choosing or giving out more then one item, then it is possible that they lack an understanding of
the amount of choices they will be making and that they may make their decisions differently. This research has much variability and is also shown to depend upon factors such as culture (Piantadosi, Jara-Ettinger, & Gibson, 2014). However, it provides a good basis for determining the cognitive differences in numerical knowledge that must be considered for decision making tasks. For this reason, I tested children 4 years of age and older in my selection tasks.

Given that there is some evidence that children use a diversification heuristic, I assume that children will also demonstrate diversification in the candy bowl task. I can then move onto hypotheses regarding partition dependence in children. I have no reason to expect that children have greater expertise or preference in this candy domain than adults, and therefore they should not be less susceptible to partition dependence. Also, the physical partitioning is cognitively simple, requiring minimal verbal skills and no memorization; children should not lack any of the skills needed to complete the task, including numeracy. I predicted that children would show partition dependence. A finding of partition dependence in children would be the first demonstration of the tendency outside of an adult age group.

Through my first three experiments, I explore the effect of partition dependence on adults’ and children’s selection choices. In Experiment 1, I attempt to replicate in adults and extend to children a finding of partition dependence in a selection task, specifically a candy bowl task (Fox et al., 2005; Experiment 4). Participants were presented bowls of candy partitioned by type and asked to select five candies as in Fox et al. (2005). In Experiment 2, I repeated experiment 1 with a
new sample of adults. In Experiment 3, I adjusted the methods to more closely match Fox et al. (2005) to tease apart the possible explanations for the results of Experiments 1 and 2. I conducted Experiment 3 with only an adult population due to the methodological changes in candy type.

**Experiment 1**

We asked whether adults’ and children’s choices from real, simultaneously presented candy options would be influenced by the arbitrary physical partitioning of the options, as previously reported in adults (Fox et al., 2005). A previous diversification task in children demonstrated that children do tend to select a variety of items (Read & Loewenstein, 1995). I expected children to diversify their choices across the candy in Experiment 1. I also predicted that children would base their selections on the bowl presentations by selecting more candies from the single-candy bowls relative to the double-candy bowl; this finding would provide evidence for partition dependence in children. Specifically, it would demonstrate that children exhibit partition dependence in selections tasks occurring with real, physical partitions. With no reason to think otherwise, and with the large demonstration of partition dependence in adults, I expected to replicate the original finding in adults.

The present candy-bowl task used the methods of Fox et al. (2005), with a few exceptions as noted.

**Method**
Participants. Seventy adults (\(M_{age} = 20.4\) years, range = 18 - 22 years, 35 females) and eighty children (\(M_{age} = 6;10\), range = 4;0 - 9;7, 40 females) participated and were included in analyses. Eleven additional children were excluded due to non-compliance or interference from guardians. Sample size was based on previous work (Fox et al., 2005). Adult participants were undergraduate and graduate students at Wesleyan University.

Stimuli. As in the original study, four types of candy were arranged across three bowls. However, because the candy types in the original study of Fox et al. (2005) were unsuitable for young children (e.g., mints, chewing gum, potential choking hazards), small chocolate bars were used (Twix, Hershey’s, Kit Kat, and Nestlé Crunch). Snack sized (miniature) candy bars were used to keep candy sizes approximately the same. Additionally, clear bowls were used in the present experiment; though bowl color was not described in the published report, the study used bowls of three different colors.

Counterbalancing. There were two possible physical arrangements of the candy types and two possible bowl orders, for a total of four counterbalancing conditions. The two possible physical arrangements of the candy types were as follows: types 1 and 2 (Hershey’s and Kit Kat) appeared in single-candy bowls and types 3 and 4 (Twix and Nestlé Crunch) appeared in the double-candy bowl, or types 3 and 4 appeared in the single-candy bowls and types 1 and 2 appeared in the double-candy bowl. The two possible bowl orders were, from left to right, single-item/single-
item/double-items and double-items/single-item/single-item. This led to the following conditions:

a) Bowl 1: Hershey’s, Bowl 2: Kit Kat, Bowl 3: Twix & Nestlé Crunch
b) Bowl 1: Twix, Bowl 2: Nestlé Crunch, Bowl 3: Hershey’s & Kit Kat
c) Bowl 1: Kit Kat & Hershey’s, Bowl 2: Twix, Bowl 3: Nestlé Crunch
d) Bowl 1: Twix & Nestlé Crunch, Bowl 2: Hershey’s, Bowl 3: Kit Kat

The first two conditions are single/single/double, while the last two are double/single/single. This counterbalancing is important to ensure that participants who simply select five candies in sequential order from left to right (or right to left) do not systematically influence the tally of choices for each bowl.

Each candy type appeared an equal number of times in single and double item bowls in relation to itself. Candy types also appeared equally in the different bowl positions. Unopened full bags of each candy type were displayed behind the bowls to illustrate that no candy was scarce. The bowls of candy were refilled after participants chose to keep the candy levels equal. Scarcity of candy could indicate the increased desirability of one candy.

Procedure. Adults completed the task in a laboratory room or at a university student center. Children participated during candy-themed holiday events at the Connecticut Science Center and a local Connecticut school.

During the original study (Fox et al., 2005), participants were presented with this set-up and were asked to choose five pieces of candy to put into a bag to take home with them. Their backs were turned to the rest of the room so that other
participants and experimenters could not see their choices. After they chose their candies, they were asked how many of each candy type they chose, how much they liked each candy (from 1 meaning “do not like it at all” to 7 meaning “like it very much”), and how much they thought other study participants liked each candy (from 1 to 7).

In my current experiment, following participants candy selections, complexity and number of questions were simplified; participants were only asked their favorite candy of the present options. While the original study hid participants’ choices from all potential viewers, my set-up did not allow for that. Participants’ choices were hidden from other participants, but were visible to experimenters.

Coders recorded the amount of candy chosen of each type from each bowl and the order in which each piece of candy was chosen. After the choice task was done, children were asked which one of the candy types they preferred. The script used by the experimenter is as follows:

“Hi! Would you like to choose some candy?

(Wait for affirmative response)

Okay, all you have to do is pick 5 candies to take home with you! They can be whichever candy you want.

(Record choices)

Thank you!

Out of these candies, which is your favorite?”
To summarize, my candy bowl tasks (Experiments 1 and 2) differed from Fox et al.’s (2005) in a few specific ways. As mentioned in the description of the candy bowl task in Fox et al. (2005), there were two single-item bowls and one double-item bowl displayed to participants. It is not confirmed whether the location of the double-item bowl was counterbalanced. For the following studies, counterbalancing included two left-to-right bowl/box orders. Half the participants see the double-category in the leftmost position, and the other half sees it in the rightmost position.

There were two other main procedural differences from Fox et al. (2005), which I stated previously: I changed the types of candies to be more suitable for young children, and I used clear bowls. Smaller procedural differences included the simplifying of post-choice questions and the visibility of participants to experimenters.

**Results**

Adults did not choose more candies from the single-candy bowls \((M = 2.50, SD = 1.10)\) compared to the hypothesized chance value of 2.5 candies, \(t(69) = 0, p = .500\), one-tailed. There were no effects of bowl order on choice (average number chosen from the single-candy bowl did not differ across conditions, \(p > .250\)). The data revealed no evidence of partition dependence: the arbitrary distribution of the candies across bowls did not affect adults’ choices of candy.

Children chose more candies overall from the two single-candy bowls \((M = 2.70, SD = 1.10)\) than the hypothesized chance value of 2.5 candies, \(t(79) = 1.63, p = \)
.053, one-tailed. Although these findings initially appeared consistent with partition
dependence, qualitative observations from the experiment suggested individual
differences in choosing patterns. Further inspection revealed that the difference from
hypothesized chance value arose from the extreme choices, or “anti-diversification”,
of a small number of individuals. These anti-diversifiers chose all of the same candy
type, displaying extreme preferences. When data from participants who chose all 5 of
the same candy type were excluded (n = 5 children), the remaining children did not
choose more than half from the single-candy bowls (M = 2.55, SD = 0.95), t(74) =
0.43, p = .340, one-tailed. There were no effects of bowl order on choice (average
number chosen from the single-candy bowl did not differ across conditions, p > .250).
Thus there is no evidence of partition dependence at the group-level of the remaining
children (75/80 participants).

Though I did not find partition dependence in adults’ choices, the child results
prompted the question of whether anti-diversifiers could have influenced adults’
group-level results. The adult data was reanalyzed after removing participants who
chose all 5 of the same candy type (n = 4), but results did not change; the choices
from the single-candy bowls (M = 2.50, SD = 0.95) again did not differ from the
hypothesized chance value of 2.5 candies, t(65) = 0, p = .500, one-tailed.

**Discussion**

This experiment found no evidence of partition dependence in the candy bowl
task in adults. Children also did not appear to make partition dependent choices.
Although children’s group-level patterns of choice seemed consistent with partition dependence, children did not show partition dependence after participants with strong preferences were removed from the group analyses. The few anti-diversifiers who chose all of one candy type drove the initial evidence for partition dependence. Candy locations were varied so that, on average, candy preferences should be distributed evenly across bowl types. However, the strong preferences and corresponding selections of a few individuals were sufficient to create the initial appearance of partition dependence in the group. The results of Experiment 1 lead to a claim that is distinct from previous reports that strong preferences are associated with a reduction in partition dependence. Here, only a small portion of children did not diversify as a result of strong preference \((n = 5)\); these children chose the same candy type five times. The remaining participants \((n = 75)\) did show a bias towards diversification, but their choices showed no sign of being influenced by the partitioning of candies over bowls.

There are arguments that a different mechanism than maximum entropy could cause partition dependence. In that scenario, anti-diversification could also result in partition dependence. The child results do not show evidence of “anti-diversification” partition dependence. The majority of children demonstrated diversification. While the five children who chose five of the same candy type made all of their choices from the single-candy bowls, this small \(n\) is insufficient to provide evidence of partition dependence among anti-diversifiers. With the small \(n\) of anti-diversifiers, their choices are more explained by chance and by preference.
Experiment 2

Experiment 1 did not provide evidence that adults display partition dependence in the candy bowl task. This finding is especially surprising given the previous finding in Fox et al. (2005) that the partitioning of candies into bowls influenced adults’ choices in an almost identical task.

Before pursuing further partition dependence studies with children, I aimed to determine whether the original finding could be replicated with adults. If the findings cannot be replicated in adults, then a different task would have to be used to test for partition dependence in children. I therefore repeated the same candy bowl experiment with a new group of adults.

Method

Participants. Sixty-nine adults ($M_{age} = 20.7$ years, range = 20-25 years, 45 females) participated. Participants were recruited at Wesleyan University; participants were undergraduate and graduate students at the university.

Procedure, Stimuli, & Counterbalancing. The procedure was identical to that of Experiment 1. Stimuli and counterbalancing also remained the same.

Results

Adults did not choose more candies from the single-candy bowls ($M = 2.59$, $SD = 1.13$) compared to the hypothesized chance value of 2.5 candies, $t(68) = 0.69$, $p$
As in Experiment 1, I reanalyzed the data after removing participants who chose all 5 of the same candy type (n = 7); the choices from the single-candy bowls (M = 2.48, SD = 0.84) again did not differ from the hypothesized chance value of 2.5 candies, t(61) = -.15, p = 0.441, one-tailed. There were no effects of bowl order on choice (average number chosen from the single-candy bowl did not differ across conditions, p > .250). There was no evidence of partition dependence in this task; the arbitrary bowl partitioning of the candies did not affect adults’ choices.

Discussion

This finding is consistent with the Experiment 1 findings. Across two studies, there is no evidence that children’s or adults’ decisions in the present candy bowl task match patterns predicted by partition dependence. However, these experiments did not use a procedure identical to that of Fox et al. (2005). It is possible that small procedural differences led to the present failure to find partition dependence effects. Experiment 3 tests this possibility.

Experiment 3

In Experiments 1 and 2, there was evidence that adults do not show partition dependence in the candy bowl task. Experiment 1 also suggested that children do not show partition dependence in the task, though evidence was less clear. Because prior work (Fox et al., 2005) reported that the same task did produce partition dependence in adults, this result is unexpected. This leads to two possible conclusions. The first is
that adults and children do not show partition dependence in the candy bowl task and
the finding in Fox et al. (2005) cannot be replicated, nor extended. The second
possible conclusion is that the small methodological differences in Experiments 1 and
2 led to the non-replication of the adult results found in Fox et al.’s (2005) candy
bowl study. To my knowledge, other than the possible change in counterbalancing,
the differences in the choice task of Experiment 2 were the choice of candy, the color
of the bowls, the simplified preference questions, and the observation by
experimenters. The preference questions followed selection, so this change could not
have an impact on participant choices.

Additionally, previous research has shown that public choices increase
diversification in comparison to private choices (Ratner & Kahn, 2002); the
observation by experimenters therefore should not have caused decreases in
diversification or partition dependence. However, it is possible that the use of
distinctly colored bowls (rather than three identical clear bowls, as used in
Experiment 2) is important for creating perceptually distinct partitions. Previous
studies have shown that partitions of varying colors draw more attention and increase
the impact of partitions (Cheema & Soman, 2008). In Experiment 3, I replicated the
procedure of Experiment 2, except that I used the same candy types and bowl colors
used in Fox et al. (2005). I again had experimenters observe participant choices for
coding and kept the simplified preference question. If the bowl colors and candy
types are critical aspects of the study, then partition dependence should appear in
adults with these matched methods. If partition dependence still does not appear, then
it will be reasonable to conclude that the candy bowl task does not prompt partition
dependence in adults or in children.

Method

Participants. Eighty adults (\(M_{\text{age}} = 20.6\) years, range = 18 - 42 years, 46 females) participated. Participants were again recruited at Wesleyan University; most adults were college-aged university students.

Procedure, Stimuli, & Counterbalancing. The method was identical to that of Experiment 2, except that I used the same candy types (Smarties, Bazooka Bubble Gum, Tootsie Rolls, and Starlight Mints) and bowl colors (green, yellow, and orange) used by Fox et al. (2005). Adult participants were again tested in a laboratory setting or in a student center. I continued to use the counterbalancing scheme described for Experiments 1 and 2. Since the bowl colors’ only purpose is to make the bowl partitions increasingly salient, no data was kept on the patterns of bowl colors used for participants. However, every condition used only one bowl of each color.

Results

Participants again did not choose more candies from the single-candy bowls \((M = 2.49, SD = 1.52)\) compared to the hypothesized chance value of 2.5 candies, \(t(79) = -0.07, p = .471\), one-tailed. Results were similar when I excluded participants \((n = 11)\) who chose all 5 of the same candy type \((M = 2.52, SD = 1.29\) from the single-candy bowls vs. \(M = 2.48\) from the double-candy bowl), \(t(68) = 0.14, p = .444\),
one-tailed. An independent samples t-test revealed an effect of bowl order on choice in the full sample; fewer candies were chosen from single-candy bowls in the single/single/double condition ($M = 2.00$, $SD = 1.32$) than the double/single/single condition ($M = 2.98$, $SD = 1.56$), $t(78) = -3.02$, $p = .003$, two-tailed. The bowl order effect was not significant without the 11 participants who chose all 5 of the same candy type ($M = 2.29$, $SD = 1.15$ vs. $M = 2.76$, $SD = 1.39$, respectively, for the two bowl orders), $t(67) = -1.56$, $p = .120$, two-tailed (suggesting that the bowl order effect may have been driven by the chance locations of the candy types chosen by individuals with particularly strong preferences). As in Experiments 1 and 2, there was no evidence of partition dependence in this task; the arbitrary distribution of the candies across bowls did not affect choices.

**Discussion**

Adults’ patterns of choosing were consistent with diversification bias. However, there was no evidence of partition dependence in this task; the arbitrary distribution of the candies across bowls did not affect adults’ choices of candy.

This finding solidified the conclusion that the candy bowl task does not elicit partition dependence in either adults or children. With my combined sample size of $N = 299$ from Experiments 1, 2, and 3, it is reasonable to conclude that the present arbitrary physical partitioning of candy does not influence the choices of adults or children.
This result conflicts with the previous finding of Fox et al. (2005), which offered evidence for adult partition dependence in the candy bowl task. Hypotheses for this disagreement are reviewed in the general discussion.

**Partition Dependence in Selection General Discussion**

In three experiments, I investigated the phenomenon of partition dependence in children’s and adults’ consumer choice, specifically in the candy choice task of Fox et al. (2005). My two goals were to replicate the prior finding of partition dependence in this candy task in adults, and to extend finding of partition dependence to younger populations. Through these experiments, with $N = 299$ participants in total, there was no evidence that arbitrary bowl partitioning affects the choices of adults or children in this multi-item selection task.

Experiments 1 and 2 used the task of Fox et al. (2005) with altered candy types and bowl colors. If participants demonstrated partition dependence, they would have chosen more candies from the single-candy bowls that the double-candy bowl. However, this was not the case for children or adults. Experiment 3 was conducted with methods that matched those of Fox et al. (2005), reverting back to the previously used candy types and bowl colors. The only known difference in procedure, besides the possible counterbalancing change, is live coding by experimenters. Experiment 3 again resulted in a non-replication of the partition dependence finding in adults, with adults’ decisions appearing unaffected by the bowl partitioning.
I considered the potential explanations for these partition independent results. As previously mentioned, heightened preference and expertise lead to decreased susceptibility to partition dependence (Fox et al., 2005). If the participants in my three studies had stronger preferences in or increased expertise about the presented candy options, then they would be expected to show lower levels of partition dependence. Alternatively, the participants in Fox et al. (2005) could have had weaker preferences and less experience in the candy types. However, adult participants in both studies were university students (mostly undergraduate) in the eastern United States; there is no reason to suspect such a substantial difference in the populations tested.

Another explanation for the results is that the counterbalancing differences in bowl orders led to the differences in results. However, I did not detect significant effects of bowl order in Experiments 1 or 2; additionally the effect of bowl order was non-significant in Experiment 3 when anti-diversifiers were removed from the analysis.

A third explanation for the differences is the setting of the studies. While the procedures were closely matched, the context and setting of the Fox et al. (2005) candy bowl task may have allowed for partition dependence in a way that my experiment did not. In the prior study, university students received course credit for research participation and completed the candy choice during an hour-long set of unrelated tasks. In the present studies, the task was conducted independently; nearly all of the adults chose candy during a brief encounter in the student center outside of a lab setting. They participated without going through written consent due to the
minimal nature of the task, writing only their name and age down on a sign-in sheet. Similarly, all of the children in my experiment chose candy in an entirely naturalistic setting. If participants (or children’s guardians) questioned the experimenter about the nature of the task, experimenters mentioned that the task was part of a psychology lab project. The setting and nature of the task suggests a minimal if not nonexistent experimental demand. If experimenter expectancy effects influenced the task in the Fox et al. (2005) study, then this alteration could account for the non-replications in Experiment 1, 2, and 3.

A fourth possible explanation for the present non-replications is that the appearance of partition dependence in the previous study was due to chance. The present data show that, even with thorough counterbalancing of candy types across the bowls, the anti-diversification choices of a few participants can create the appearance of partition dependence in the group. This chance result occurred in Experiment 1, in which children’s candy choices initially appeared consistent with partition dependence (more candies taken from single-candy bowls overall). However, this effect was entirely driven by a handful of individuals (n = 5 out of 80) who chose all 5 candies of the same type, all of which happened to be located in single-candy bowls. The sample size and counterbalancing were not efficient to counteract the effects of the few individuals who exhibited extreme choices, leading to an initial suggestion of partition dependence. Outlier choosing behavior in any partition dependence task can lead to the appearance or non-appearance of partition dependence. It additionally could have been possible for the data to end up skewed in
the opposite direction if the anti-diversifying participants chose their five candies from the double-item bowls, hence why I conducted analyses for all three experiments without the anti-diversifiers.

The adult data from Experiments 1, 2, and 3 did not show evidence of partition dependence before or after removing anti-diversifiers from analyses. A strong possibility is that a portion of participants in the prior Fox et al. (2005) study drove the partition dependence effect by chance.

With the lack of partition dependence findings in the diversifying participants of these three experiments, the second goal remained: do children exhibit partition dependence? The candy bowl task was not definitive enough to test this question after the non-replication in adults. I decided to continue the investigation into children’s partition dependence with a new task.
Partition Dependence in Allocation Investigation

Continuing the exploration into children’s decision making, my hypothesis remains that children’s choices are prone to partition dependence. There are several reasons for hypothesizing that children’s choices, like adults’, will be influenced by the groupings of options. As mentioned previously, children show a tendency towards diversification, one of the mechanisms leading to partition dependence (Read & Loewenstein, 1995). However, the referenced study does not test the existence of other maximum entropy tendencies in children that also lead to partition dependence.

Maximum entropy heuristics are relied on more heavily in situations of minimum information, when people are naïve decision makers. When people have greater expertise, maximum entropy heuristics are less relied upon. Children should behave more naïvely than adults in decision making settings. Therefore, with minimal information facilitating maximum entropy heuristics, children should rely on these heuristics to a greater degree.

Also as described earlier, children as young as 12 months could spontaneously categorize objects and children as young as 4-years-old could understand an object belonging to multiple categories (Bornstein & Arterberry, 2010; Nguyen & Girgis, 2014). Children therefore should have the ability to recognize and understand groupings of objects, possibly using these groupings while making decisions. However, it is also possible that category salience is an important factor in children’s use of categories, with some categories being too weak for children to draw upon them. With the lack of research on developmental changes in partition dependence, it
is possible that partitioning influences develop through increased exposure to partitions and experience with decision making. In this scenario, partition dependence may not result until late childhood, adolescence, or adulthood.

To test the development of partition dependence, the challenge remained of using a task that is appropriate for children of young ages. I again aimed to avoid complex hypothetical situations that would require higher levels of reasoning and abstract thought. I decided to adapt a resource allocation study that found partition dependence in adults’ decisions. I developed a resource allocation task appropriate for children as young as 3-years-old to assess whether the grouping of the target options would influence children’s allocations to those options. In Experiment 4, I administered the novel resource allocation task to a group of older children ages 7- to 10-years-old. In Experiment 4, I administered the same allocation task to a group of younger children ages 3- to 6-years-old. Following the two experiments, I collapsed the data and asked whether developmental change occurred in children’s partition-dependent resource allocation— that is, whether older or younger children were more susceptible to partition dependence. Lastly in Experiment 6, I began exploring the behavior of adults in the novel allocation task.

Related studies in adults have found that arbitrary groupings shape decisions about how to distribute resources. For example, in the study mentioned previously in this thesis, partitioning of recipient groups affected the way that adults allocated resources to those groups (Fox et al., 2005). Adult participants were asked to distribute financial aid resources to applicants of various income groups (Fox et al.,
The income levels were divided at different brackets for two different conditions, with one condition (low income partition) having a larger range of less wealthy financial aid applicants and one condition (high income partition) having a larger range of more wealthy applicants. In the low income partition, income brackets were $15,000 per year or less, $15,001–$30,000 per year, $30,001–$45,000 per year, $45,001–$60,000 per year, $60,001–$75,000 per year, and more than $75,000 per year. In the high income partition, incomes brackets were $75,000 per year or less, $75,001–$85,000 per year, $85,001–$100,000 per year, $100,001–$120,000 per year, $120,001–$145,000 per year, and more than $145,000 per year. When the low-income households were arbitrarily partitioned into more different categories (low-income partition), adults allocated increased financial aid to low-income households compared to when the low-income households were partitioned into fewer categories (high-income partition). The novel resource task in the next three studies parallels the financial aid task in a child-friendly setting.

Through these three experiments, I explore partition dependence in children’s and adults’ resource allocation. In Experiment 4, I ask older children to distribute resources to animals at the zoo by using a physical set-up. Experiment 4 addresses the question of partition dependence in older children in resource allocation tasks as opposed to selection tasks. Experiment 5 was conducted with younger children in the same novel resource allocation task to explore partition dependence. Experiment 6 used the same procedure but with adults to attempt to extend the findings onto this population.
Experiment 4

Experiments 1-3 did not result in partition dependence in children’s decisions, and revealed a failure to replicate a previous finding of partition dependence in adults, even with closely matched methods. I conclude that the candy bowl task (a task that involves real-world choices from physically presented partitions and options) does not elicit partition dependence in children or adults.

However, partition dependence in adults’ decisions has been shown across a variety of tasks and situations. Many of these tasks involve resource allocation (deciding how to distribute funds) and judgments (judging the possibility of an outcome) rather than selection as in the candy bowl task. It is possible that the arbitrary categorization of options may influence decision making in children when they are asked to allocate resources or judge possibilities unlike in the candy bowl task.

Resource allocation tasks appeared more easily adapted to a physical setting in comparison to judgment tasks. To test the possibility of partition dependence in children during resource allocation, I developed a novel task that parallels the candy bowl task in a few respects (an arbitrary 3-way partition of containers and a 4-way partition of distinct elements within the containers). This task is more directly related to previous resource allocation tasks done with adults, such as a hypothetical financial aid task (Fox et al., 2005)
In the present experiment, children ages seven- to ten-years-old were asked to distribute tokens representing food to four different kinds of zoo animals, arranged across three boxes. As in the candy bowl task, I looked for the influence of the arbitrary box partition on children’s allocations; this would provide evidence of partition dependence.

The set-up mirrored the arrangement of Experiments 1-3 such that two boxes were each associated with one type of animal, while the third box was associated with two animals. This task, like the candy bowl task, involves an arbitrary three-way partition of containers (the boxes the animals were associated with) and a natural four-way partition of specific entities (the animals themselves). If children do not demonstrate any partition dependence and distribute tokens solely across animal types, then half of their allocations should go to the two single-animal boxes combined and half should go to the double-animal box. If, however, children do show partition dependence and allocate resources based solely on the boxes, then two thirds of allocations should go to the single-animal boxes combined, and one third should go to the double-animal box. Children can also fall in between these two extremes, by relying on both box partitions and animal partitions, allocating between ½ and 2/3 to the single-animal boxes combined, and between ½ and 1/3 to the double-animal box. Allocations biased toward 2/3 and 1/3 for single-animal boxes and double-animal boxes, respectively, would show evidence for partition dependence.

Previous research suggests that the last hypothesis of falling between the two extremes is most likely. In resource allocation tasks, partition dependence has been
attributed to the maximum entropy heuristic of naïve diversification. In these tasks, people tend to allocate resources evenly across the categories, but also adjust allocations slightly based on the items contained in the groupings. People incorporate partition information and some individual entity information into their decisions, leading to less complete partitioning effects.

In this present novel task, these older children should behave even more naïvely than adults and should not have strong preferences among the similar animal types. Therefore, I predict that children will show partition dependence in this task, allocating more than half of the food tokens to the single-animal boxes.

For these allocation tasks, I tested children 3 years of age and older. I used a slightly younger sample than in the selection tasks due to the turn-taking strategy documented in younger children.

Method

Participants. Eighty-two children ($M_{age} = 8;8$ years, range = 7;0-11;9 years, 51 females) participated in the experiment and were included in analyses. Five additional participants were excluded due to interference from guardians or siblings, or experimenter error.

Stimuli. A table was set-up with three white boxes in a single row (about 22 cm x 12 cm x 15 cm, with small openings just large enough for the tokens) with one white hook-and-loop fastener of even length on the front of each box. The remaining stimuli were hidden out of sight from participants behind the boxes.
Four photos of large cats typically found at a zoo (a leopard, cheetah, panther, and tiger) were used as the recipient groups. The photos were approximately the same size (about 80 cm$^2$) and were created using Adobe Illustrator. These animals were selected to be different enough that they could be easily distinguished, but similar enough that children would be unlikely to have strong preferences. The photos were affixed to the boxes with hook-and-loop fasteners.

**Procedure.** Children participated in a laboratory room, at the Connecticut Science Center, or at a town event.

Children were first shown a gender-neutral puppet, named “Alex.” Gender neutrality was conveyed with an ambiguous hairstyle, outfit, and name. He/she pronouns were avoided and only the “they” pronoun was used.

The researcher stated that Alex had some food to give to the animals at the zoo and that Alex wanted to be fair. The researcher asked the child to help Alex distribute the food to the animals. Children were given twelve “food” tokens (small wooden discs, 2-inch diameter) in a small bowl, and were told that they could place the tokens in any of three white boxes to indicate how much food they would like to give to different kinds of animals. During the course of the experiment, two of the boxes each become marked with a single, distinct animal photo (single-animal boxes), and the third box becomes marked with two distinct animal photos (double-animal box; see Figure 4). Animals were assigned and fastened in front of the child in order to convey that box/animal associations were arbitrary (paralleling related adult studies, in which explicit verbal descriptions convey the arbitrariness of partitions).
To do this, the experimenter said, “Hmmm, let’s put the food for all of the (animal type) at the zoo in this box!” while affixing the animal photo to the boxes. After all of the animals were placed on the boxes, children were given a small bowl with the twelve food tokens. Children were told that the food tokens placed in each box would go to the kind(s) of animal(s) appearing on that box, and that they could allocate the food however they wished.

![Figure 4. Three boxes were displayed with two boxes displaying one animal each and one box displaying two animals. Slits on the top of boxes allowed food tokens to be placed inside for the animals.](image)

After food tokens were distributed, children were asked which animal they preferred. Some children did not distribute all twelve of the tokens. These children were prompted to give out the remaining pieces until all of the pieces were distributed.

The script experimenters used was as follows:

“Would you like to play a game with me?

This is my friend Alex! Alex has some food to give to animals at the zoo. Alex wants to be fair. Can you help Alex give out the food?

Hmm...let’s put the food for all of the (animal type) in this box.

(velcro cat to single box)
Hmm...let’s put the food for all of the (animal type) in this box.

(velcro cat to single box)

Hmm...let’s put the food for all of the (animal type) and all of the (animal type) in this box.

(velcro two cats to the double box)

Ready to help Alex give out the food?

(Give bowl containing food circles to child)

You can put it in the boxes however you like.

Which animal do you like best?

Great job! Thanks for playing.”

Counterbalancing. There were two possible physical arrangements of the animal types and box orders, for a total of four counterbalancing conditions. This closely matched the counterbalancing procedures of Experiments 1 – 3. The two possible physical arrangements of the animal photos were: leopard and cheetah on single-animal boxes and panther and tiger together on the double-animal box, or the panther and tiger on the single-animal boxes and the leopard and cheetah on the double-animal box. The two possible box orders were, from left to right: single/single/double and double/single/single. This led to the following conditions:

a) Box 1: Leopard, Box 2: Tiger, Box 3: Panther & Cheetah
b) Box 1: Panther, Box 2: Cheetah, Box 3: Leopard & Tiger
c) Box 1: Tiger & Leopard, Box 2: Cheetah, Box 3: Panther
d) Box 1: Cheetah & Panther, Box 2: Tiger, Box 3: Leopard

Each animal appeared an equal number of times with each type of box and in each position.

**Results**

Children distributed more than half of the 12 tokens to single-animal boxes, $M = 7.27$, $SD = 1.02$, $t(81) = 11.27$, $p < .001$, $d = 1.24$, one-tailed; this is consistent with partition dependence. Token distribution to single-animal boxes did not differ between the single/single/double box order ($M = 7.08$, $SD = 1.01$) and double/single/single box order ($M = 7.44$, $SD = 1.01$); $t(80) = -1.64$, $p = .106$). No children allocated more than 8 tokens to a single box. Thus the arbitrary box partition did influence children’s allocations.

**Discussion**

This group of children ages 7- to 10-years-old chose to allocate more resources to the single-animal boxes than to the double-animal box. I interpret these results to mean that the arbitrary box partitions influenced children’s decision; the partitions nudged participants to allocate more tokens to animals on the single-animal boxes. These results could not have been driven by anti-diversification allocation patterns. Every participant diversified allocations across the boxes, with no child giving more than 6 out of the 12 tokens to one of the boxes.
Experiment 5

In Experiment 4, relatively older children (aged 7-10) participated in a resource allocation task; the arbitrary partitioning of the available options influenced their allocations. In Experiment 5, I used the same novel resource allocation task to explore partition dependence in even younger children, ages 3- to 6-years-old. Following this experiment, I assessed whether partition dependence strength differed between the two age groups; a difference would suggest a developmental change in partition dependence.

Methods

Participants. Seventy-seven children ($M_{age} = 5;3$ years, range = 3;1- 6;9 years, 39 females) participated in the experiment and were included in analyses. Seven additional participants were excluded due to noncompliance, interference from family members, or experimenter error.

Procedure. The procedure was identical to Experiment 4, except younger children were tested.

Results

Children distributed more than half of the 12 tokens to single-animal boxes overall, $M = 7.87$, $SD = 1.61$, $t(76) = 10.20$, $p < .001$, $d = 1.16$, one-tailed. Some children allocated all 12 tokens to one box ($n = 3$); I repeated analyses with these children excluded, but still more than half the tokens were distributed to single-
animal boxes, $M = 7.86, SD = 1.17, t(73) = 13.66, p < .001, d = 1.59$, one-tailed. No children allocated 11/12 tokens to single-animal boxes, one child allocated 10/12, and no children allocated 9/12. Token distribution to single-animal boxes did not differ between the single/single/double box order ($M = 7.69, SD = 1.11$) and double/single/single box order ($M = 8.03, SD = 1.22$), $t(72) = -1.25, p = .216$. The arbitrary box partition influenced young children’s allocations in this task.

To test for developmental change in partition dependence, I combined data across experiments. There was a negative correlation between tokens distributed to single-animal boxes and age in months, Pearson’s $r = -.256, N = 159, p = .001$. As age increases, the number of tokens allocated to single-animal boxes decreases: younger children’s allocations appear more susceptible to partitioning effects in this task.

**Discussion**

These findings show that preschool-aged children as young as 3 years old demonstrate partition dependence in this novel resource allocation task, much like older children. In fact, the younger children exhibit a greater degree of partition dependence than do the older children of Experiment 4. The partition dependence patterns found in the current experiment are facilitated by diversification; the small number of anti-diversifiers who tended towards extreme allocation (distributed 9 or more resources to the same box, $n = 5$) did not produce the partition dependence effect.
The results of Experiment 4 and 5 are consistent with prior findings that arbitrary groupings influence adults’ resource allocations (e.g., Fox et al., 2005). However, the current task has some significant alterations from previous resource allocation tasks, including the physical set-up of options. I decided to attempt to extend this novel resource allocation task onto an adult population.

**Experiment 6**

Experiment 4 and 5 demonstrated the effect of partition dependence in children. One possible explanation is that children, like adults, show partition dependence in resource allocation tasks. Another possible explanation is that only children show partition dependence in the animal resource allocation task. Children and adults may be influenced by partitions in different contexts and to different degrees across these contexts. I attempted to replicate the findings of Experiments 4 and 5 in adults to determine if children and adults show the same patterns.

If adults do not show the same pattern of choosing as children in this task, then I can conclude that the story of partition dependence is not simple; different tasks may elicit partition dependence in different populations. In this case, many more studies would be needed to determine the nature of partition dependence. If adults do show the same pattern of choosing as children in this task, then I can conclude that this novel resource allocation task has a similar effect on adults’ decisions as hypothetical allocation tasks.
The data for Experiment 6 is still being collected, and thus the following analyses and results are preliminary.

Methods

Participants. Sixty adults ($M_{age} = 23.3$ years, range = 18 – 67 years, 31 females) participated in the experiment and were included in analyses. Seven participants did not indicate their birthdates and were not included in age statistics. Three additional participants were excluded due to noncompliance or experimenter error.

Procedure. The procedure was identical to Experiments 4 and 5, except adults were tested in a laboratory setting in addition to a museum setting. Due to the juvenile nature of the puppet “Alex”, adults were told the experiment was designed for children before beginning.

Results

At the group level, adults marginally distributed more than half of the 12 tokens to single-animal boxes overall, $M = 6.23$, $SD = .70$, $t(59) = 2.59$, $p < .01$, one-tailed. There was no effect of box order, $t(58) = -1.10$, $p = 0.275$.

However, a closer look at the individual data revealed that most adults ($n = 52$ out of 60) did not distribute more tokens to the single-animal boxes. Only 13.3 % of participants ($n = 8$) allocated more than 6 tokens to the single-animal boxes. These results suggest that the novel resource allocation partitions may have an effect on a
small percentage of adults. I did not reach the participant count achieved in previous studies in this thesis. These analyses remain preliminary.

**Discussion**

With the preliminary results of Experiment 6, partitions have a minimal yet significant effect on adult choices at a group level. While most adults did not distribute more than 6 tokens to single-animal boxes, 13.3% of participants did allot more than the chance value. This ties in well with Experiments 4 and 5, which show that younger children were more influenced by the partitions than older children. More adult participants are needed to draw a stronger conclusion about their behavior in this novel resource allocation task.

**Partition Dependence in Allocation Discussion**

The allocation investigation shows that children’s decisions are subject to partition dependence. While children did not show partition dependence in the candy bowl selection task, this novel resource allocation task elicited partition dependence in both younger and older age groups. Younger children exhibit a greater degree of partition dependence in this context. This finding shows that partition dependence effects do not require increased exposure to decision making, but rather are present in children as young as 3 years old. Since younger children demonstrated a greater degree of partition dependence, there may be an interaction between partition dependence and age.
Additionally, adults showed only minimal evidence of partition dependence. This finding suggests that partition dependence may manifest differently in children’s and adult’s decisions. Further data collection and research is needed to study the developmental changes in partition dependence.

These studies present the first finding of partition dependence in children’s decisions. This new developmental exploration opens the way for further partition dependence tasks to be conducted in children to determine the extent of its influence on children’s choices. The allocation tasks suggest that people of younger ages may be more influenced by partitions. This may be due to the decreased knowledge of younger persons, which in turn may increase reliance on ignorance priors and maximum entropy heuristics. Additionally, different types of partitions and tasks may affect adults and children to different degrees.
General Discussion

Throughout six studies, I have raised and answered several questions. In my selection studies, participants chose five candies from partitioned bowls. I found conclusive evidence that the candy selection paradigm does not elicit partition dependence in children or adults: previous findings from Fox et al. (2005) could not be replicated. In the allocation investigation, I developed a novel resource allocation task in which participants distributed food tokens to zoo animals partitioned across boxes. I found evidence that arbitrary group partitions do influence decisions of both older and younger children, with younger children showing stronger partition dependence. Preliminary data from an ongoing sixth experiment suggest, however, that adults may not be affected by the arbitrary partitions in the resource allocation task.

The lack of partition dependence in the candy bowl selection task is surprising; I consider some explanations. For the finding of partition dependence in the Fox et al. (2005), my preferred hypothesis is that the sample size was not large enough to avoid chance results. In my data, with a sample size based on the previous work, I initially found a choice pattern in children consistent with partition dependence; however, the pattern disappeared after excluding children who chose five of the same candy type. Adult data did not support a finding of partition dependence both before and after removing participants who chose five of the same candy. I found a pattern of choice consistent with partitioning in the child sample due to the outlier choices of a few children. My evidence suggests the same explanation is
possible for Fox et al.’s (2005) result. The extreme choices of a few individuals may have caused the appearance of partition dependence within the whole sample.

As for why the candy bowl task does not induce partition dependence, I believe there are a few possibilities. The first is that the bowl partitions were too arbitrary to influence choices. While arbitrariness has been studied as a moderating factor, and studies have claimed that arbitrariness does not decrease the influence of partitions, it is possible that this effect is confined to hypothetical situations. Arbitrariness in real-world tasks may indeed have a moderating effect. The bowls may have not created a salient enough partition. Additionally, the grouped candies (in the two-candy bowl) may have not been similar enough to merit grouping or may not have been dissimilar enough from the non-grouped candies to create their own category. Similarity and distinctions within and between groups is shown to be important for how decision-makers form groups (Shah & Oppenheimer, 2011).

A future study could be conducted with altered candy types to give the groupings greater perceptual or thematic distinctions. If the double-candy bowl held two chocolate candy types (Hershey’s and KitKats) and the two single-candy bowls held two non-chocolate candy types (mints and bubble gum), then the contrast between groups may cause the partitions to influence choices. It may be that the specific candy combinations used in the selection tasks (both the original types and the chocolate types) were not distinct enough between groups or similar enough within groups to elicit partition dependence. Alternatively, it is possible that the physical partition of bowls was not salient enough. However, separate bowls seem
comparable to, if not stronger than, the written headings that signify partitions in other studies.

While the evidence in the allocation studies point to partition dependence, I also consider other interpretations of the data. During the task, children place the food tokens into three equally sized boxes to “feed” the four animal breeds. I interpreted the results as children distributing equally among the three boxes due to a partitioning effect. However, it is possible that children distributed equally over volume. In other words, children may have tended to distribute four tokens to each square volume of boxes. If the double-box with two cats on it were instead twice as big as the two single-cat boxes, children distributing by volume would be expected to double their allocations to the double-item (double-volume) box. If this result occurs in a follow-up study, then this would be evidence in conflict with a partition dependence explanation.

Another explanation is that children attribute meaning to the partitions, and still follow a fairness norm. Participants may think that the two grouped animals are grouped because each has smaller populations in comparison to the animals placed on their own boxes. If participants are basing their allocations on this inference, then children’s choices are still following an equality norm. This would be a significant result showing that partitioned groupings have the power to influence perceptions of population.
Potential Limitations

A few limitations exist in my studies, and in many partition dependence studies. The main limitations I discuss here are the real-world applicability of studies and the psychological mechanisms driving partition dependence. Much remains to be explored to pinpoint the mechanisms behind partition-dependence. I opened this thesis discussing the two-system model of decision making, linking the phenomenon of partition dependence to the automatic system 1. To test this theory, we could see if greater cognitive concentration and awareness of the arbitrary groupings during a partitioning study diminishes the partition dependence effect. Additionally, there may be different mechanisms at play for each of the different partition dependence domains. The selection tasks with personal choosing behavior may use different cognitive pathways than an allocation or probability judgment task. Lastly, it is possible that social norms are contributing to people’s reliance on partitions since variety seeking and therefore partition dependence occur more often in public than in private settings (Ratner & Kahn, 2002). Yet, social norms would not explain situations when people spontaneously create their own mental partitions.

Another limitation is that many partition dependence studies exist in the hypothetical. Most do not involve real choices and almost none are real-world (i.e. they occur outside of a laboratory context). One of the few real studies, the candy bowl task, I have shown to fail in eliciting partition dependence. Evidence suggests that partition dependence does have an effect on real-world decisions and is applicable to public policies, however the present candy bowl findings suggest that
there is a limit to partition dependence’s effect on real choices (Yamada & Kim, 2016). The real-world applications need to continue to be explored to lend insight into the generalizability of past research.

In light of my non-replication result from my selection tasks, I consider the possible issue of partition dependence in hypothetical, real, and real-world settings. Most partition dependence studies occur in hypothetical settings, however my selection studies, I argue, are real-world because they involve actual choosing behavior outside of a laboratory setting. Participants received little to no indication that the task was directly associated with a lab study. I did create the partitions and ask people to choose from them, but intentional partitions also occur in real-world settings. Evidence for partition dependence has been found, for example, in non-experimental data of macroeconomic indicators and horse race betting (Sonnemann, Camerer, Fox, & Langer 2013).

Additionally my allocation studies involve physical distribution, though here the physical task falls in a grey area between hypothetical and real. The allocated “food” and recipient animals are not real, however participants are really giving to these imaginary groups. A follow-up study is needed that creates a novel real-world allocation task.

The results in this thesis do not demonstrate any tendencies toward partition dependence in adults. These results do indicate that we need to continue exploring the real-world applicability of partition dependence, researching partition dependence’s limits and scope. In the candy bowl task, the partitions may have been too arbitrary to
affect decisions. Additionally, the lack of similarity of the grouped entities may lead to a lack of rationality behind the partitions and therefore not result in partition dependence (Shah & Oppenheimer, 2011). Another avenue to further explore is whether adults are less susceptible to partition dependence when individual entities are more salient than partitions of the entities. In the resource allocation task, the animal types may be more salient than the boxes they are associated with; a full set of data may lend insight into this salience question.

For choice architects hoping to judge decisions, it may be important to create coherent partitions. Additionally, the reverse could be true for nudging people away from partition dependence. If people’s attentions are directed towards the irrationality of groupings, they may become less partition dependent.

**Implications for Everyday Life**

Partition dependence is applicable to many situations outside of a laboratory setting. Partitions, for example, are present in political conversations and may be having effects on constituents and government officials. Recent political conversation around ethnic and religious populations in the United States have been described through partitions that can create negative impressions of specific groups. Imagine, for example, that students of the U.S. are described in the following way: “Among U.S. students, some students are good at mathematics, some students are bad at mathematics, and some students are atrocious at mathematics.” Based on that statement, how many students out of a hypothetical 100 students would a person say
are good at math? If people’s partition dependence affects population judgments, then it is very likely that the ignorance prior will cause people to guess that about 1/3 of people are good at math since the population was divided into three categories (good, bad, and atrocious at math).

The underestimation of populations with fewer partition groups and overestimation of populations with more partition groups could have important consequences. Donald Trump was quoted speaking about Mexican immigrants in the U.S.: some Mexicans are “bringing drugs”, some are “bringing crime”, some are “rapists”, and some “are good people” (Newstex, 2015). The ignorance prior in this situation suggests that only ¼ of Mexican immigrants are good people, whereas ¾ are therefore not good people, but rather people associated with illicit activity.

Similarly, partitioning language may affect perceptions on topics such as abortion. Abortions are many times described in terms of the reasons behind the abortion and the weeks at which an abortion is performed. Abortions are frequently listed as occurring either in the first 13 weeks, 14 to 22 weeks, 22 to 28 weeks, and past 28 weeks; this may cause overestimation of the number of people receiving abortions in the second and third trimester, when in actuality about 90% of abortions occur in the first 13 weeks (Jatlaoui et al., 2013). Misconceptions and misjudgments like these can lead to inappropriate policies and behaviors in regards to these topics, such as laws limiting immigration and forbidding abortions. Partitioning language can also be co-opted to reflect reality and better inform decisions.
One effect of partition dependence evidenced from several studies is that more choices are chosen from individually grouped items and more allocations are made to individually grouped recipients. This effect can be used when listing options to nudge decisions. For example, to push people towards healthier food options, a grocery store can label foods as belonging to the categories of “vegetables”, “fruits”, “non-produce;” this would hypothetically increase purchases of the individually listed fruits and vegetables as opposed to if they were included in a “produce” grouping. One experiment demonstrated the effect that partitions can have on healthier lifestyles; grocery carts were partitioned into sections with one section for holding fruits and vegetables and another section for holding other grocery items (Wansink, Smith, Payne & Tal, 2011). These partitioned grocery carts made shoppers’ decisions more salient to themselves and increased the purchases of fruits and vegetables.

These possible effects are equally important for children’s judgments and choices. Children can also form impressions of groups and of rules based on the conversations (and partitions) surrounding them. Additionally, there are many topics specifically relevant to children that can be impacted by partition dependence. As mentioned earlier, partitioning of options and partitioning language may affect aspects of children’s identities, careers, and health. Children encounter partitions when deciding how to spend their extra-curricular time, which foods to consume, which activities they engage in with friends, and what to do when a problem occurs. Children are often taught in class that they can either partake in bullying, watch bullying happen, or intervene in bullying; this leads to many bystanders witnessing
bad situations. If instead children were taught that they could be a part of bullying (by watching or partaking in bullying) or they could stop bullying, then bystander interventions may increase as an effect of these partitions.

Additionally, partitions have been shown to affect reliance on other heuristics and norms in adults and therefore may have similar effects in children. In the financial aid study conducted in adults by Fox et al. (2005), partitions shifted the norm reliance from a need norm to an equality-fairness norm. Partitioning may also influence children’s adherence to norms. The relationship may work in the opposite direction as well, with developmental aspects affecting partition dependence in children. Children’s concepts of fairness and adherence to allocation norms, mathematics skills, and salience-dependent recognition may influence partition dependence in children.

**Future Directions**

There are a few directions that I believe partition dependence research should go into to contribute the most insight into the phenomenon. Developmentally, I document here the first finding of partition dependence in children. Future work can research whether partitioning in selection tasks and judgment tasks also influence children’s decision patterns. Developmental research across the human lifespan would also be significant. Decision making in older adults is under risk in many settings; it is possible that partition dependence would manifest differently in an older adult population than in a college-age sample (Peters, Hess, Västfjäll, & Auman,
2007). This would be an important finding about older adults’ decisions, especially in terms of crucial healthcare related decisions.

   Additionally, partition dependence effects are lessened, though not extinguished, by increased preference, salience of preferences, information, and expertise. Future studies in partition dependence research could continue to look at moderating factors. Moderating factors could be used to help individuals overcome partition dependence when partitions may lead to negative outcomes. In situations where partitions are not already constructed, it is suggested that experts will end up subconsciously partitioning the space anyway. In these situations, combining the assessments of multiple experts who most likely partitioned the space in different ways can moderate self-induced partition dependence (Bordley, 2009). Compromising decisions made from different partitions of the same space, therefore would lead to less partition dependence in the final decision. Having one person make multiple judgments with different partitions may also help to inoculate a person against partition dependence by showing them the inconsistencies in their own decisions (Clemen & Ulu, 2008). Related to this suggestion, I hypothesize that educating people about partition dependence would lead to less partition dependence in people’s decisions. Other research also suggests that partition dependence effects can be moderated if a person can think about whether their current decision is consistent with their previous decisions (Prava, Clemen, Hobbs, & Kenney, 2016).

   I previously touched upon the ways that partition dependence could be used to better public policy and minimize misconceptions about reality. We should
understand the real-world scope of partition dependence to successfully apply partitions for actual outcomes. For real-world application, research should continue to move from hypothetical situations to real and even real-world settings. I hypothesize that important factors in real-world settings would be the coherence of partitions, the domain of the task, and the personal investment in the outcome. In hypothetical situations, tasks have little to no personal involvement without any concrete benefit to the participant. In real-world situations, allocations to third-parties and judgment tasks may still have no benefit for the participant, whereas selection tasks and allocation tasks involving personal involvement would have a potential benefit to the participant. This possible relationship between personal benefit and partition dependence could lend insight into real-world behavior.

Connections to Other Work

Partition dependence has implications for other psychological research and cognitive tendencies. One implication is that partitioning of options affects people’s escalation of commitment (Kwong & Wong, 2014). People’s commitment to a course of action escalates when the chosen option is partitioned into multiple sub-options. However, people’s commitment deescalates when the alternative (not-chosen) options are partitioned into multiple sub-options. Partitions can also have an effect on motivation during tasks when rewards are partitioned into different categories (Wiltermuth & Gino, 2013). When two rewards were partitioned into different categories, people were more motivated to earn both rewards in comparison to when
the two rewards were partitioned into the same category. Partitions are also related to attention and self-control; people are more able to constrain themselves from consumption of food or gambles when their desired item is partitioned into categories (Cheema & Soman, 2008). The partitions draw greater consumer attention to the desired item and consumption behavior, providing a greater opportunity for deliberate self-control. A similar outcome was found in a food guideline study that instructed people to remember to partition their dinner plate in half and fill this half plate partition with vegetables for their meals (Riis & Ratner, 2010). Participants were better able to remember and follow the partitioned plate food guideline better than an alternative food pyramid guideline. These observations support the importance of partition dependence both inside and outside an experimental setting.

**Conclusions**

This thesis project has answered four main questions and also accomplished two other subsequent goals. I began by accomplishing the goal of detailing a bulk of existing partition dependence literature and related areas of diversification bias, maximum entropy heuristics, and system 1 and 2 decision making. Following this review, I answered my three main questions. First, I provided evidence that the candy bowl selection task of Fox et al. (2005) cannot be replicated and the task does not evoke partition dependence in adults. This finding questions the criteria under which adult’s decisions are partition dependent in physical, real settings. Second, I provided evidence that children’s decisions are also not partition dependent in a similar candy
bowl task. Third, I provided the first evidence of partition dependence in children through a novel resource allocation task in which children distributed food resources to zoo animals. Younger children displayed a stronger partition dependence effect than older children, suggesting a developmental change. This evidence opens up a slew of questions regarding the extent to which children’s decisions are affected by partitions. Fourth and last, I find that adult’s decisions were not affected by partitions in the same novel resource task. This suggests that there are developmental differences in partition dependence. Finally, I ended this thesis with my final goal—explaining the relevance and significance of partition dependence in real-world settings. Partition dependence has been non-experimentally observed in real-life situations and I hypothesize it could be relevant for innumerable other situations. More research in this field will help clarify the scope of partition dependence in real-world settings and also tease apart its developmental aspects. Partition dependence has numerous impacts on real-world decisions and is relevant to both adults’ and children’s decision making.
References


Evolution and Human Behavior, 33(6), 736-745.


