

The development of the sunk cost bias

by

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The following serves on the Examining Committee for this thesis. The decision of the Examining Committee is by majority vote.

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### **Author's Declaration**

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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### **Statement of Contributions**

I am either the majority contributor or sole contributor to all of the work presented in this thesis. This includes Chapters 2, 3, and 4 of my thesis which are publications co-authored with my supervisors Dr. Ori Friedman and Dr. Stephanie Denison. Citations and information regarding these publications can be found in the relevant chapters.

## **Abstract**

The sunk cost bias is when people overvalue objects or projects because they have already invested time, money, or effort into them. Most sunk cost research over the past 50 years investigated the bias in adults, exploring the conditions in which people expect themselves and others to be biased by sunk costs. However, very little work has examined the developmental origins of the bias, despite much evidence that young children reason about costs for a host of predictions and inferences about others. Across three papers, this dissertation examines children's ( $N = 990$ ) and adults' ( $N = 934$ ) sunk cost predictions. Chapter Two first explored whether children predict others' actions are biased by sunk costs. After seeing agents collect two identical objects but being able to keep only one, adults expected agents will be biased by sunk costs and choose high-cost objects. However, 5- to 6-year-olds chose between high- and low-cost objects equally. Across four experiments, children consistently failed to anticipate that sunk costs biased others' choices, their own hypothetical choices, or their choices in interpersonal contexts where costs are sunk by others. Children were not insensitive to costs, though, as children predicted agents would collect low-cost objects in the future. Together, the findings from this chapter show that children do not anticipate sunk cost bias across various scenarios. Chapter 3 tested between two accounts for why children overlook sunk costs when predicting actions. On one account, children do not see sunk costs as causing future outcomes, while on another, they can recognize this causal link but do not see actions as avoiding losses. In three experiments, 5-7-year-olds again did not expect sunk costs to bias others' actions, as they responded at chance when predicting which objects agents would keep. However, children reasoned about sunk costs to predict emotion, anticipating that agents would feel sadder about high-cost objects.

Together, the findings of this chapter support the view that children see sunk costs as causally relevant but do not expect actions to compensate for losses. Chapter Four examined whether children can be prompted to anticipate the sunk cost bias. Before predicting which objects agents would keep, children were asked about effort, waste, or negative emotion. In three experiments, children around age 6 predicted the sunk cost bias when prompted with effort and around age 7 when prompted with waste. Prompting children with waste did not always lead to sunk cost predictions, though, and children only showed some sensitivity to predicting the bias with negative emotion. Overall, this dissertation shows that children do not spontaneously predict the sunk cost bias. Yet, children are not entirely unable to reason about sunk costs, as they can recognize how sunk costs relate to waste, effort, and negative emotion, and predict the bias when prompted. This work deepens our understanding of children's cost-based reasoning and the developmental trajectory of the sunk cost bias. This work also contributes to theories of the bias and raises questions about the role of experience and theory of mind in the emergence of sunk cost predictions.

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## **Dedication**

For my husband whose love is the unseen scaffold.

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## Chapter One: General Introduction

In everyday life, people try to minimize the costs of their actions. They use laundry machines instead of hand-washing clothes, take shorter routes on their morning commute, buy items on sale rather than at full price, and plan meals to reduce food waste. These examples show how people strive to minimize the *costs*—effort, time, money, and resources—required to achieve their goals. Minimizing the prospective costs of goals is efficient because it allows resources to be allocated toward future goals.

People's choices are also shaped by their reasoning about costs that have already been incurred in the past. For example, imagine an artist spends three weeks creating a sculpture for an upcoming contest. As the deadline draws near, a flash of inspiration strikes, and in just a few minutes she creates another sculpture. She likes it just as much as her first sculpture and thinks it is equally likely to win, but she can only submit one to the contest. Which one will she choose? People typically predict that she will submit her first sculpture because she spent more time and effort on it. If she submits the new sculpture, it feels as though the time and effort she spent on the other was wasted.

People's tendency to honor irrecoverable past investments is known as the *sunk cost bias*. The bias leads people to prefer options with greater sunk costs over options with less sunk costs, even when high-cost options are less appealing. According to microeconomic theory, making decisions based on sunk costs is irrational (Arkes, 1996; Arkes & Ayton, 1999; Arkes & Blumer, 1985; Thaler, 1980) because past investments are irrecoverable and do not affect future outcomes. In the artist example, choosing the original sculpture might seem to salvage the time and effort spent. However, it really makes no difference because her time and effort is lost, regardless of which sculpture is chosen.

Over the past 50 years, most work on sunk cost bias has investigated adults, exploring their predictions about their own choices (e.g., Arkes & Blumer, 1985; Garland & Newport, 1991) and others' choices in hypothetical vignettes (e.g., Bornstein & Chapman, 1995). Findings suggest the sunk cost bias is widespread: Adults predict they and others will show the bias in diverse situations involving many kinds of sunk costs, including expenditures of money (e.g., Arkes & Blumer, 1985), time (e.g., Bornstein & Chapman, 1995), and effort (e.g., Dijkstra & Hong, 2019). Adults also honor others' sunk costs in their own decisions (Olivola, 2018). Some behavioral studies show that people are also biased by sunk costs in real-world choices (e.g., Navarro & Fantino, 2009; Staw & Hoang, 1995; but see Devoto & DeFulio, 2022).

While there is almost no work on sunk costs with children, much developmental research has shown that young children—and even infants—are adept at considering prospective costs when predicting actions (e.g., Gergely et al., 1995; Gönül & Paulus, 2021; for a review, see Gergely & Csibra, 2003), inferring preferences and competencies (Jara-Ettinger et al., 2015; 2020; Pesowski et al., 2016), and making sociomoral evaluations (Jara-Ettinger et al., 2016; Zhao & Kushnir, 2023). These findings illustrate that from a young age, people anticipate others will behave rationally in light of their beliefs, desires, and constraints (e.g., Cushman, 2020; Gergely & Csibra, 2003; Leslie et al., 2005). It remains an open question for whether children's reasoning about costs includes sunk costs. Like adults, sunk costs may influence children's predictions of their own and others' behavior, suggesting that children reason about costs regardless of whether they have already been incurred. Alternatively, children may not predict the sunk cost bias and only consider prospective costs when predicting actions.

This dissertation investigates the development of sunk cost reasoning, exploring whether, when, and how children use sunk costs to predict actions. There are two major reasons for

conducting this inquiry. First, prior work has shown that people reason about costs from an early age—young children reason about costs to make predictions and judgments about others' actions, choices, and preferences. While this suggests that children understand the connection between costs and value, it is unclear whether their cost-based reasoning involves sunk costs. Hence, this work has the potential to deepen our understanding of how children reason about costs. Second, several theories propose why people predict the sunk cost bias, and understanding the developmental trajectory of how children reason about sunk costs could further reveal why sunk cost predictions emerge. In the following sections, I begin with an overview of cost-based reasoning in childhood before turning to the evidence of the sunk cost bias and proposals for why it occurs.

### **Reasoning about costs**

Costs guide people's expectations of others' actions from early in life. Many studies show that infants consider costs when attributing intentionality and capacity for goal-directed actions to an agent (e.g., Csibra et al., 1999; Phillips & Wellman, 2005; Scott & Baillargeon, 2013; Skerry et al., 2013) and collaborative teams (Mascaro & Csibra, 2022). In one seminal study, one-year-olds saw an agent jump over a wall to reach a target. After, infants' looking time data suggested they expected the agent to minimize costs in the future: With the wall removed, infants expected the agent to go straight instead of jumping. This suggests that infants did not expect the agent to jump, as this is a costly and inefficient action (Gergely et al., 1995; for a review, see Gergely & Csibra, 2003). However, infants did not expect the agent would go straight if their initial action was costly—if the agent jumped for no reason when approaching the goal. In a similar study, 6-month-olds looked longer when an agent jumped high over a low wall than when they jumped only the necessary height (Liu & Spelke, 2017). Even infants

*themselves* minimize costs—18-month-olds prefer crawling a short path to their mother over a longer one (Paulus & Sodian, 2015), and selectively persist toward costly goals when they are likely to succeed (Lucca et al., 2020).

By early childhood, people can explicitly judge and predict others' actions based on costs. Around four years old, children expect a character to take a shorter path to a goal than a longer one (Gönül & Paulus, 2021) and choose a simpler task to receive a reward over a more complex one (Bennett-Pierre et al., 2018). They also judge that characters who achieve goals efficiently did a better job than ones who achieved their goals inefficiently (Sehl et al., in preparation). Beyond predicting and evaluating actions, children also use costs to infer others' goals. In one study, 4- to 5-year-olds observed characters incurring minimal or additional costs to achieve a goal (e.g., collecting sticks from the ground vs. reaching for them in a tree to make a campfire). Children judged that the character bearing additional costs was more likely to be playing, suggesting they see unnecessary costs as uncharacteristic of goal-directed actions (Chu & Schulz, 2023).

Costs also allow children to infer others' preferences and competence. In one study, 5-6-year-olds observed an agent choosing between two objects placed on shelves, and children were asked which one the agent preferred (Jara-Ettinger et al., 2015; 2016; see also Pesowski et al., 2016). When both objects were on low shelves, children easily inferred that the chosen object was the one the agent preferred. However, when one object was placed on a low shelf and the other on a high shelf, children did not infer that the agent preferred the object chosen from the low shelf. Instead, they understood that the agent must have chosen the object from the low shelf because it was more accessible, not because the agent liked it more. Turning to competence, if children see that an agent likes an object but does not incur high costs to obtain it (e.g., climbing

a high shelf), they infer that the agent is physically incapable of obtaining it (Jara-Ettinger et al., 2015).

Finally, costs also shape children's sociomoral inferences and evaluations. In one study, 4- to 9-year-olds heard stories where agents felt obligated to help others but faced either a high physical cost (e.g., climbing a tall flight of stairs to find a toy) or a low physical cost (e.g., looking behind a sofa to find a toy). From around age 6, children allocated more prizes and rated agents as nicer when they helped at a higher cost (Zhao & Kushnir, 2023; see also McCrink et al., 2010). Children also infer agents should help others with difficult tasks than easy ones (Bennett-Pierre et al., 2018), and teach others challenging causal relationships over simpler ones (Bridgers et al., 2016). This suggests children view help and instruction as more valuable when they minimize others' costs (see Powell, 2022). Younger children may also understand the social value of costly helping—children around age 4 prefer taking credit for high-cost helping actions than low-cost ones (Katz et al., 2024). At the same time, children recognize that agents can be excused from helping when costs are high. For example, in one study, toddlers watched two puppets try to help activate a toy: One succeeded easily while the other needed multiple attempts (Jara-Ettinger et al., 2015). When both puppets later refused to help activate the toy, toddlers judged that the incompetent puppet was nicer, suggesting that toddlers exonerated the puppet from helping because it was more costly for them (for related infant work, see Woo et al., 2024). Children also consider the recipient's need in conjunction with the cost of helping when evaluating others (e.g., Radovanovic et al., 2023). For instance, children find it permissible for agents to refuse helping when it is costly and the need is low (e.g., missing a movie to help with homework) but impermissible when it is costly and the need is high (e.g., helping someone climb down from a tall height; Sierksma et al., 2014; see also Finiasz et al., 2025).

In sum, children consider costs when predicting actions, judging choices, inferring preferences, and making sociomoral evaluations. These abilities stem from a foundational understanding of the relationship between value and costs. For instance, children anticipate that agents will effortfully obtain objects they like but not those they dislike, and infer agents are incompetent and not nice if they do not incur costs to obtain objects they or others like. These findings reflect children's reasoning about this cost-value relationship in one direction: The value of an object determines the costs others will incur in the *future* to obtain it. A crucial yet overlooked aspect of children's reasoning about costs is whether they also understand the relationship of cost and value in the reverse direction: The costs others incurred in the *past* in obtaining an object can affect how much they value it—for instance, how motivated they are to keep it. If children can anticipate the sunk cost bias, it would suggest their reasoning about costs extends beyond predicting future costs based on value to include how sunk costs influence value. In the next section, I review evidence for the sunk cost bias in adults and discuss existing theoretical accounts for the bias, before returning to the discussion of sunk cost predictions in childhood.

## **Evidence for the sunk cost bias in adults**

### ***Vignette studies***

The sunk cost bias has been examined in contexts varying in realism, perspective, choice type, investment type, and investment amount. Most studies use hypothetical vignettes in which adults read scenarios and are asked to imagine what *they* would choose (Dijkstra & Hong, 2019; Garland, 1990; Klaczynski, 2001; van Putten et al., 2010), or what *others* might choose (e.g., Bornstein & Chapman, 1995). One classic vignette is the TV dinner scenario (Arkes & Blumer, 1985) in which participants imagined buying a discounted \$3 TV dinner for themselves, and later

purchasing an identical one for a friend at the regular price of \$5. They then learn that their friend could no longer join them and so they must decide which dinner to eat and which to throw away. Participants could either choose to eat the \$3 dinner or the \$5 dinner, or indicate that they have no preference between the two. Since the dinners are identical, it should not matter which dinner is eaten and which is thrown away. However, only 76% of participants chose the ‘no preference’ option while the remainder chose the \$5 dinner. This suggests that people were biased by the costs sunk into the more expensive dinner and were reluctant to let it go to waste.

Other vignettes involve choosing objects of differing value. In another experiment by Arkes & Blumer (1985), participants imagined accidentally booking two non-refundable ski vacations for the same weekend: One was expensive, the other cheap but expected to be more enjoyable. Since both vacations were already paid for and the costs irrecoverable, participants should have chosen the vacation they preferred. However, participants predicted they would choose the more expensive trip, even though they knew it would be less enjoyable. This vignette, along with others involving choices between objects of differing value, demonstrate that people’s bias by sunk costs can override their preferences or expected enjoyment. Moreover, people are even biased by sunk costs that were incurred by *others*. When imagining that two friends had each purchased a trip for them on the same day, people were again more likely to choose the expensive, less-enjoyable trip (Olivola, 2018). This demonstrates an interpersonal sunk cost effect, where people are influenced by others’ investments despite having no sunk costs themselves (see also Gunia et al., 2009).

### ***Behavioral studies***

The sunk cost bias has also been observed in behavioral studies in laboratories (Cunha & Caldieraro, 2009; Navarro & Fantino, 2009; Ronayne et al., 2021) and real-world settings

(McCarthy et al., 1993; Staw & Hoang, 1995). For example, participants in one study organized hundreds of playing cards for 10 minutes (low sunk cost) or 50 minutes (high sunk cost; Navarro & Fantino, 2009). When deciding how to spend the remaining 15 minutes of the study, participants with higher sunk costs preferred continuing to organize cards, while those with lower sunk costs preferred working on a questionnaire. Importantly, participants were far from completing the task, so their choice to persist was not driven by the near completion of the task. In another study, researchers investigated whether draft order affected NBA players' time on the court. Although we might expect teams to prioritize their most productive players (e.g., top performance, no injury, etc.), draft order predicted playing time even after controlling for player productivity (Staw & Hoang, 1995). This provides real-world evidence that coaches were biased towards athletes they had invested in during the draft, likely in an attempt to justify their original choice.

Choices in these behavioral studies may align with those in hypothetical vignettes (e.g., Ronayne et al., 2021; for a meta-analysis, see Roth et al., 2015). However, some studies suggest that people are less likely to be biased by sunk costs in real-world settings than in hypothetical vignettes (Devoto & DeFulio, 2022; Friedman et al., 2007). This discrepancy raises the possibility that *predicting* the bias in hypothetical vignettes involves different reasoning than *exhibiting* the bias in real life. These differences may reflect the contributions of adults' conceptions of irrational choice or the role of theory of mind when predicting others' choices (for a discussion, see Howard et al., 2024).

Several factors influence people's susceptibility to the sunk cost bias. People are more likely to predict the sunk cost bias when they invested more (e.g., Arkes & Blumer, 1985; Rego et al., 2018), feel a greater personal responsibility for success (Navarro & Fantino, 2009; Staw,

1976), have a longer temporal horizon (Strough et al., 2014), or when the scenario provokes negative emotions (Dijkstra & Hong, 2019). Individual differences, such as rumination (van Putten et al., 2010), cognitive reflection (Ronayne et al., 2021), and cultural influences (Yoder et al., 2014) also play a role in sunk cost reasoning. Interventions like budgeting (Heath, 1995) and sunk cost education can mitigate the bias (Tan & Yates, 1995); however, even professionals with expertise in accounting or banking honor sunk costs (Garland & Newport, 1991; Staw, 1976). As Roth et al. (2015) noted, “apparently individuals are not able to transfer the knowledge they obtain in their professional life to their everyday life” (p. 120).

### ***Types of sunk cost scenarios***

Before turning to explanations for the sunk cost bias, it is important to distinguish between two types of sunk cost scenarios: *progress* and *adoption* decisions (Moon et al., 2001; Roth et al., 2015). The sunk cost bias is often associated with progress decisions, in which the decision maker has already invested substantial resources into an object or project but has not yet fully ‘paid for’ or completed it. The decision maker then learns that the object is no longer worth acquiring or the project is likely to fail, and the choice is whether to continue investing or to withdraw entirely. In one classic scenario, participants imagined they were the president of an airline company developing a new plane, and were told they had either invested 90% of research funds into it or nothing at all (Arkes & Blumer, 1985). Upon learning the project would likely fail, participants with prior investment mostly chose to continue funding the project with the remaining funds, whereas those without any prior investment chose to allocate money elsewhere. In another scenario, participants were more likely to predict they would continue watching a boring movie if they had paid for it compared to when it was free (Frisch, 1993; see also Strough et al., 2008; Olivola, 2018). In these examples, people choose to invest more money and time

because of their sunk costs—they feel committed to finishing what they started. They may also feel that it is too late to quit, or that further investment might salvage the situation (e.g., the airplane is successful; the movie becomes entertaining). However, the rational choice is to cut losses and abandon these efforts in favor of redirecting remaining effort toward more worthwhile endeavors.

Adoption scenarios involve a different choice structure, requiring the choice between two options with different sunk costs, such as in the TV dinner and ski vacation scenarios (Arkes & Blumer, 1985). The decision maker has already paid for or invested in both options, but must choose between them due to practical constraints—they are not hungry enough to eat both dinners, can only be in one place at a time (e.g., ski vacation), or are restricted by a rule (e.g., one submission to an art exhibit; Baron et al., 1993). People are biased by sunk costs if they choose high-cost options over low-cost ones, even when low-cost options are unattractive. For instance, in the ski trip example, people select the more expensive trip even though it is less enjoyable (Arkes & Blumer, 1985). Some scenarios even offer an additional ‘no preference’ choice, such as in the TV dinner scenario, and yet many people forgo that option and select the more expensive dinner. Some adoption scenarios involve only investing in one object, though. In another scenario participants imagined they either paid for or received a free ticket to a basketball game. When a snowstorm began, they considered whether they would rather watch the game from home. Participants only predicted they would brave the snowstorm when they paid for the ticket, but preferred to stay home when it was free (Thaler, 1980; see also Gourville & Soman, 1998).<sup>1</sup>

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<sup>1</sup> This scenario also involves elements of progress scenarios, as it involves persisting in going to the game or shifting to watch the game at home. However, this choice is not a progress scenario because the ticket was already obtained, and the choice is not whether to continue investing in it.

Progress and adoption decisions have some elements in common: Both involve irrecoverable sunk costs and choices about the future. Given these similarities, most literature makes little distinction between them (Moon, 2001) especially since the bias is equally prevalent in both decision types (Roth et al., 2015). However, despite their similarities, treating them interchangeably overlooks key differences, such as the extent to which further investment is required. In adoption scenarios, the objects are acquired or the project is completed, and the choice is between two options that have differing amounts of sunk costs. In contrast, in progress scenarios, the object is not fully acquired (or the project is not yet completed), and additional costs are required to achieve the goal. This decision, then, involves whether to continue sinking costs in hopes of reaching the goal. People might be biased by sunk costs for different reasons across these scenarios. For instance, people may be drawn to continue investing in progress scenarios due to their escalation of commitment (e.g., Schaubroeck & Davis, 1994) or a desire for completion (e.g., Conlon & Garland, 1993). However, these considerations cannot explain why people choose high-cost objects over low-cost ones in adoption scenarios, as this choice not involve further investment (for a discussion, see Roth et al., 2015).<sup>2</sup>

### **Reasons why people are biased by sunk costs**

Many theoretical accounts offer proposals for why people predict they and others are biased by sunk costs. One predominant theory is that people overgeneralize rules about waste (Arkes, 1996; Arkes & Ayton, 1999; Arkes & Hutzel, 1997; Larrick et al., 1990; see also Bornstein & Chapman, 1999). People typically try to avoid waste in their everyday behavior by

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<sup>2</sup> Beyond this distinction, scenarios can also differ in how they measure people's bias by sunk costs. Some present a choice between two options, with a preference for high-cost options over low-cost ones as indicating bias (e.g., airplane and ski trip scenarios). Others offer a 'no preference' option, where failing to select it indicates bias (e.g., TV dinner scenario). Finally, some involve comparing responses across two analogous scenarios—either involving sunk costs and the other not—with differing choices revealing bias (e.g., hotel movie and basketball game scenarios).

adhering to basic principles, like *make full use of purchases* and *avoid overspending* (Arkes, 1996). These are sensible and practical principles that usually foster prudent economic choices, helping people avoid wasting time, money, effort, and resources. The sunk cost bias may result, though, from people erroneously misapplying these principles.<sup>3</sup> For instance, in the artist example, people may predict the artist will choose the sculpture she worked harder on, fearing that the time and effort she spent on it would be wasted. Similarly, in the TV dinner scenario, it seems like \$5 is wasted if the \$3 dinner is eaten. In these examples, thinking about waste is erroneous because the costs are already incurred and are not recovered by choosing high-cost options.

People may also make sunk cost predictions by anticipating negative emotions, like sadness or regret (Arkes, 1996; Dijkstra & Hong, 2019; Wong & Kwong, 2007; see also Arkes & Blumer, 1985). On this proposal, people choose high-cost options to minimize anticipated negative emotions. For example, in the artist scenario, people think the artist would feel upset about abandoning the project she worked harder on and even regret the time she spent on it. So, people predict she will submit this sculpture for the contest to avoid these negative emotions. Consistent with this account, negative emotions like anger, frustration, and regret influence whether and how people make sunk cost predictions (Coleman, 2010; Hafenbrack et al., 2014; Kwak & Park, 2012; van Putten et al., 2010; Zeelenberg & Van Dijk, 1997). Furthermore, people's predictions for whether different kinds of agents will be biased by sunk costs relates to their judgments of whether agents have the capacity to feel regret and frustration (Howard et al., 2024).

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<sup>3</sup> Some have framed this in terms of dual-process theory, suggesting that waste functions as a heuristic applied in System 1 processing. On this view, people reflexively perceive abandoning high-cost options as wasteful but may override this bias through deliberate System 2 reasoning (e.g., Klaczynski & Cottrell, 2007; Strough et al., 2011a).

Central to these proposals is *mental accounting*—the way people categorize, track, and evaluate rewards and costs. When investing time, effort, or money into objects, people initially track the costs as a ‘loss’ in their mental account as they have not yet derived any benefit from it. Upon using the object, they track a ‘gain’ in value in the mental account and close it (e.g., the account is settled at either zero or net positive). However, if the gains fall short of the losses, the mental account remains open at a net loss. Leaving accounts open with unresolved losses makes people feel wasteful and upset as they invested in the object more than they gained (Prelec & Loewenstein, 1998; Thaler, 1985; 1999). In sunk cost scenarios, like the TV dinner scenario, two mental accounts are opened upon purchasing the dinners. Eating a meal represents a gain in value that closes the account, while leaving it uneaten results in keeping the account open. The choice, then, is whether to face a large negative balance by leaving the regular-price meal account open and eating the discounted one, or a smaller negative balance by leaving the discounted meal’s account open and eating the full-price one. People may choose to eat the full-price meal to avoid the waste and negative emotion associated with leaving this larger account open. However, the choice between the dinners is inconsequential—the meals are identical, and \$8 was spent in total regardless of which meal is chosen.<sup>4</sup>

Other proposals do not involve mental accounting at all. Some posit that people see effort as imbuing value. For instance, one proposal is effort justification (closely related to cognitive dissonance theory; Festinger, 1957). On this view, the value of an object or goal following a difficult or effortful task increases, presumably as a way to justify having invested significant effort (Aronson & Mills, 1959; Benozio & Diesendruck, 2015). In sunk cost scenarios, people

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<sup>4</sup> The choice between objects does matter in scenarios where objects differ in value. For example, in the ski vacation scenario, it makes sense for people to choose the vacation they prefer more. However, people often choose against their preference due to sunk costs.

may prefer objects with greater sunk costs to reinforce the belief that their prior investment was worthwhile (Brockner, 1992; Staw, 1976; 1981). For instance, in the artist example, abandoning the high-cost project could feel inconsistent with the effort expended to create it. The artist is then faced with reconciling why she worked on it in the first place, and might even feel that creating it was a mistake in the first place (Arkes & Ayton, 1999; Arkes, 1996). So, people may select high-cost objects to reduce this dissonance.<sup>5</sup>

Overall, these accounts offer differing explanations for why people predict the sunk cost bias. Examining the sunk cost bias in children could clarify which aspects of sunk cost reasoning are present early in development. For instance, some work suggests that children understand throwing away resources is wasteful (see Choshen-Hillel et al., 2020; Sehl et al., 2023; Sorokowska et al., 2020), though it is unknown whether they see other costs, like effort, as wasted. Similarly, while young children recognize negative events cause others' sadness (e.g., Denham et al., 1994; Fabes et al., 1988; Levine, 1995; Yuill, 1984) or regret (Weisberg & Beck, 2010), there is no evidence for whether children see sunk costs as leading to negative emotions. Investigating how children reason about sunk costs also has the potential to reveal why it occurs in the first place. For instance, children might not recognize that sunk costs can be seen as wasted, but still anticipate others will be biased by sunk costs. Such a finding would imply that waste is not as central to sunk cost reasoning as was previously thought.

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<sup>5</sup> Other explanations for the sunk cost bias have been offered but I have not reviewed some here because they only pertain to progress scenarios and not adoption ones. Some other proposals conceptually overlap with ones I already described: prospect theory (Garland & Newport, 1991; Kahneman & Tversky, 1979; Thaler, 1980), self-justification (Brockner, 1992; Staw, 1976), and adaptive learning (Pompilio et al., 2006). Some related effects also might explain the bias: effort heuristic (Kruger et al., 2004; Sweis et al., 2018), self-perception (Bem, 1967), contrast effects (see Alessandri et al., 2008; for a review of effort-based accounts, see Inzlicht et al., 2018). I briefly cover some of these explanations in Chapter 5.

## Sunk costs in childhood

Despite the extensive research on adults' sunk cost predictions, only a few papers involve young children. In one of the first studies with children, 5-12-year-olds imagined they were going to the circus with either a ticket they bought themselves or one that was given as a gift (Webley & Plaisier, 1998). The car broke down along the way, and children decided whether to pay for the bus to get to the circus or go home. Children chose to pay for the bus regardless of whether they sunk costs (paid for the ticket) or not (ticket given as a gift), whereas adults in similar studies only persisted if they had incurred costs (Thaler, 1980).<sup>6</sup>

In another study, older children ages 7-14 appeared to show the sunk cost bias when predicting others' choices (Klaczynski & Cottrell, 2004; see also Morsanyi & Handley, 2008). In this study, children imagined scenarios about a character who had an idea for an art project. In the sunk-cost scenario, the character had nearly completed the project, while in the no-sunk cost scenario, the character had not yet started it. The character then had a better idea, and children were asked whether the character would pursue the new idea or continue with the old one. When there was no sunk cost, children predicted the character would go with the new idea, recognizing it as the better option. However, when there was a sunk cost, children of all ages predicted the character would stick with their original idea, indicating they expected the character would be biased by sunk costs.

Some limitations of this study cast doubt on this finding, though. For instance, choosing the old idea was the easier option since the drawing was nearly complete. So, children may not have been biased by sunk costs—they might have predicted the character would persist with the old idea because it was the least effortful way to finish the art project. This aligns with findings

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<sup>6</sup> A new study (Hamzagic et al., 2025) was published after I completed this research. I discuss it in detail in Chapter 5.

that children predict others will minimize costs when pursuing their goals (e.g., Bennett-Pierre et al., 2018; Gönül & Paulus, 2021). Additionally, the character could only choose the new drawing if they erased the old one, so children may have selected the old drawing to avoid having the character erase it when it was nearly complete. Indeed, similar progress scenarios in adult studies do not involve erasing, taking back, or undoing their investment—they merely involve abandoning a course of action. For instance, the airline president did not have to dismantle the old plane to invest in the new one.

Only one study investigated children's predictions in adoption scenarios (Baron et al., 1993). In the first experiment, children aged 5-12 imagined scenarios where they invested time, money, or effort in objects. For example, children imagined they spent weeks working on a drawing for an art exhibit, but during the last art class, quickly drew something else they liked more. When deciding which drawing to submit to the exhibit, children chose between the drawings at chance-level, suggesting that they were not biased by the effort they put into the first drawing. However, this scenario could have been difficult for children as it requires balancing both their sunk costs and preference (much like the ski vacation scenario where one vacation was preferred more than the other; Arkes & Blumer, 1985). The second experiment gave older children a simpler scenario and still found no sunk cost effect. In this study, 7-15-year-olds were given the TV dinner scenario (Arkes & Blumer, 1985) and were mostly uncertain of which dinner they would choose, or said the choice between dinners did not matter. Only about a third of children selected the high-cost dinner, suggesting they were not biased by sunk costs.<sup>7</sup>

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<sup>7</sup> Responses in this study were interpreted differently than the original study TV dinner study (Arkes & Blumer, 1985). Adults in that study were considered to be biased by sunk costs for not always choosing the “no preference” option. However, in the Baron et al. (1993) study, children were not considered to be biased because they did not choose the high-cost over the low-cost option. If we apply the Arkes & Blumer (1985) interpretation to children's data in the Baron et al. (1993) study, children would appear to be biased by sunk costs because only 2/3 of children chose the “no preference” or “does not matter” option.

Some research did not explicitly test sunk cost bias in children but may nonetheless indicate it. In one study, 4-6-year-olds completed tasks to earn stickers and could allocate them to a stranger (Benozio & Diesendruck, 2015). The tasks were either effortful (e.g., reciting the alphabet backward) or effortless (e.g., answering simple questions like “how old are you?”). By age 6, children in the effortful condition gave away fewer stickers than those in the effortless condition, even when the stickers were unattractive. Another study had 3-6-year-olds rate two similar-looking objects, one they created and one created by someone else. From age 5, children liked the objects they created (Marsh et al., 2018; 2022; see also DeJesus et al., 2019). Both studies could suggest that children value objects more when they invested effort into obtaining or creating them, which could indicate a bias by sunk costs.

However, these findings might not reflect the sunk cost bias. Rather than responding to sunk costs, children in these tasks might have felt more attached to the objects. For instance, they could have been more engaged when completing effortful tasks, or because their efforts gave them a greater sense of deservingness or ownership. Consistent with this, some studies have found that children are no more likely to value their objects more than other ones when obtaining them required greater effort. In a follow-up study in Marsh et al., (2018), children either expended low or high effort to create their objects, and valued their own creations more than the alternatives regardless of the effort involved. Similarly, in another study, 5-7-year-olds valued toys they created more than toys created by others, but were no more likely to overvalue their objects when they were effortful to obtain than relatively effortless to obtain (Kiefer et al., 2023).

### **Developmental trajectory of sunk cost predictions**

Since the studies on the sunk cost bias in childhood yielded mixed findings, it is unknown how sunk cost reasoning develops across the lifespan. One possibility is that sunk cost

predictions decrease with age. This proposal is generally supported by research with youth and adults: Early adolescents are more biased by sunk costs than young adults (Klaczynski, 2001), and young adults are more biased by sunk costs than older adults (Bruin de Bruin et al., 2012; 2014; Del Missier et al., 2013; Eberhardt et al., 2019; Huai et al., 2023; Strough et al., 2008; 2011b; see also Roth et al., 2015). However, some studies find that the bias is stable across young to middle adulthood (Parker et al., 2018) and older adulthood (Del Missier et al., 2020). An alternative possibility is that sunk cost predictions increase with age. One proposal by Arkes & Ayton (1999) suggests that people develop sunk cost predictions with age and experience, as they learn to recognize sunk costs as leading to waste—something children have yet to encounter or fully understand. One study supports this conclusion, as older children were more biased by sunk costs than younger ones (Morsanyi & Handley, 2008), though, other studies show younger children may be just as unbiased by sunk costs as older children (Baron et al., 1993; Webley & Plaisier, 1998).

A key oversight in these proposals, however, is the lack of evidence with children. It remains unknown whether children reason about sunk costs and how they use sunk costs to predict others' actions. Without this evidence, positing developmental trajectories is premature—age trends observed in adolescents and adults cannot simply be extrapolated to young children. Overall, due to the limited research on the sunk cost effect in childhood, the development of the bias across the lifespan remains largely unknown.

### **Overview of the Dissertation**

The following three chapters advance our understanding of the development of the sunk cost bias and children's broader reasoning about costs. In all experiments, I focused solely on adoption scenarios (i.e., choices between objects). These predictions may be easier for children

because they involve a straightforward choice between two objects, whereas progress scenarios require balancing sunk costs against future investment and the likelihood of success. Adoption scenarios also offer clearer controls (e.g., sunk vs future costs) and closely align with prior research on children's reasoning about costs and value. In Chapter 5, I revisit progress scenarios and discuss this as an avenue for future developmental work.

Together, these chapters report the results of 10 experiments, in which I tested 990 4-7-year-olds and 934 adults. Chapter 2 investigates how children reason about prospective and sunk costs when predicting others' choices. Chapter 3 tests between two accounts for why children overlook the sunk cost bias. Finally, Chapter 4 examines how prompting children could lead them to predict the sunk cost bias.

### **How do young children reason about sunk costs to predict others' actions?**

Chapter 2 investigates young children's ability to predict that others will be biased by sunk costs. In the first experiment, 5-6-year-olds and adults saw sunk cost scenarios where a character collected two identical objects, one obtained at a high-cost, and one obtained at a low-cost. Participants predicted which of the two objects the character would keep. The second experiment replicated these findings in children, but also included another condition where they predicted which of the two objects the character would collect in the future. The third and fourth experiments tested first-person and interpersonal vignettes designed to further test children's consideration of sunk costs in action judgments. In all four studies, children did not anticipate the sunk cost bias, as they chose between high- and low-cost objects. However, children used prospective costs to predict actions, as they anticipated characters would collect low-cost objects in the future. These findings provide insight into how children use costs to predict actions,

providing preliminary evidence that children use prospective costs but not sunk costs to predict actions.

### **Why do children overlook the sunk cost bias?**

Chapter Three directly tests between two accounts for why children overlook the sunk cost bias. On one account, children do not see sunk costs as causal, and so do not anticipate costs will impact choices. The other account posits that children see sunk costs as causal, but unlike adults, think future actions cannot make up for sunk costs. These accounts make opposing predictions about whether children should see sunk costs as affecting emotions. In the first experiment, 4-7-year-olds and adults saw stories about characters who each collected items that were easy or difficult to obtain, and predicted which character was sadder about being unable to keep their objects. The second experiment compared emotion and action judgments. Children saw vignettes where a character collected low- and high-cost objects that turned out to be broken, and were asked which object the character would be sadder about (emotion judgment) or which one the character would fix (action judgment). The third experiment addressed concerns of the design of previous experiments, and more directly tested between emotion and action judgments by using the original vignette. Children saw a character collect low- and high-cost objects, and were asked which they would be sadder about and which they would keep.

Across three studies, children predicted that characters would feel sadder about high-cost objects over low-cost ones, but again did not anticipate that characters would keep them. These findings speak against the account that children do not see sunk costs as causal, as they saw sunk costs as leading to negative emotion. Furthermore, the findings show that costs are integrated into children's and adults' theory of emotions, and raise further questions about developmental differences in sunk cost reasoning.

## **Does prompting children with effort, waste, or negative emotion lead them to predict the sunk cost bias?**

Chapter Four further explores why children do not predict the sunk cost bias. One possibility is that children reason about sunk costs like adults, understanding that sunk costs lead to waste and negative emotions. However, unlike adults, children might not spontaneously consider waste and negative emotion when predicting others' actions. Given this possibility, children may predict the sunk cost bias if prompted with effort, waste, or negative emotion. In the first experiment, 5-7-year-olds were shown the same vignette as used in previous experiments. Immediately before being asked the action prediction, children were asked an emotion, effort, or control prompt question. In the other two experiments, children were asked waste, effort, or control prompt questions.

The findings of these three experiments show that children can predict the sunk cost bias when prompted. Contrary to what we originally thought, children are not entirely unable to make sunk cost predictions. This suggests that children's reasoning about sunk costs is not fundamentally different from that of adults. Children can recognize sunk costs involve waste, negative emotion, and effort, and when prompted, they see these factors as biasing others' choices. The findings also raise questions about why some children did not predict the bias, after having identified sunk costs as wasteful or leading to negative emotion.

## **Chapter Two**

### **Blind to bias? Young children do not anticipate that sunk costs lead to irrational choices**

A version of this paper is published:

Sehl, C. G., Friedman, O., & Denison, S. (2021). Blind to bias? Young children do not anticipate that sunk costs lead to irrational choices. *Cognitive Science*, 45(11), e13063.

People often overvalue items that they spent time, money, or effort pursuing. For example, suppose a girl picks two flowers while visiting a park, one from a small hill that is easy to climb, and the other from a large hill that is strenuous to climb. If the girl can only keep one flower, which will it be? As an adult, you likely think she will keep the flower from the big hill. Anticipating this choice suggests you expect others to be biased by *sunk costs*—past investments that cannot be recovered. Importantly, this choice to keep the high-effort flower is irrational. Choosing this flower *seems* to minimize wasting effort, even though choosing it will not recover or justify the effort spent pursuing it (Arkes, 1996; Arkes & Ayton, 1999; Arkes & Blumer, 1985; Thaler, 1980). Hence, anticipating that people are biased by sunk costs may demonstrate an understanding that choices are sometimes irrational.

The present work investigates young children's ability to anticipate that others will be sensitive to sunk costs in their choices. This ability is particularly important as people's actions and choices are often irrational (e.g., Kahneman, 2011). Successfully predicting others' actions, then, requires us to anticipate not only their rational choices, but also their irrational choices. Over the past 40 years, much developmental research has demonstrated that young children come to expect others to behave *rationally* in light of their beliefs and desires, and environmental constraints (e.g., Cushman, 2020; Gergely & Csibra, 2003; Leslie et al., 2005). For instance, two-year-olds expect others to continue searching until they find a desired object, but to cease searching once that goal is reached (Wellman & Woolley, 1990). And infants expect others to

take the most efficient, and least costly, path to a goal (e.g., Csibra & Gergely, 2007; Liu & Spelke, 2017). However, much less research has investigated whether children anticipate *irrational* behavior (see Goldwater et al., 2020 for an exception).

Investigating whether children anticipate the sunk cost bias will also be informative about their understanding of costs more generally. Recent work shows that children understand that an agent's valuation of an object determines the cost the agent is willing to incur for it (value → cost incurred; Jara-Ettinger et al., 2016; 2020; for related work in infancy, also see Liu & Spelke, 2017). For example, in one study, 5-6-year-olds saw an agent choose between a banana and a watermelon (Jara-Ettinger et al., 2015). When the fruits were equally difficult to obtain, children inferred the agent preferred whichever fruit he chose; if he chose the banana, they concluded he liked it better. But children did not infer this in a condition where the fruit he chose was easier to obtain. They presumably recognized the agent might have chosen against his preferences—the benefit of obtaining the preferred fruit might not have warranted the effort (i.e., cost).

The sunk cost bias *reverses* this relation between costs and value. The cost an agent has already incurred for an object increases its value to the agent (cost incurred → value). Again, valuing objects based on the costs previously incurred to obtain them is irrational, as past investments are not a meaningful indicator of present value (Arkes, 1996; Arkes & Ayton, 1999; Arkes & Blumer, 1985; Thaler, 1980). Hence, investigating whether young children anticipate the sunk cost bias will show whether they understand the effect of incurring costs on subjective value. Few studies have explored this question. In one study, 5-12-year-olds heard a story where they either purchased a circus ticket or received a ticket as a gift (Webley & Plaisier, 1998; see also Krouse, 1986). In the story, their car broke down and when they were asked whether they would pay for a bus to the circus, children mostly chose to pay regardless of how they had

acquired the circus ticket. This finding could suggest that children's decisions are not affected by sunk costs. However, young children often have difficulty reasoning about money, so they might be sensitive to other kinds of sunk costs (e.g., Berti & Bombi, 1981). A few other studies have explored sunk costs in much older children, mostly adolescents, and yielded mixed results (e.g., Baron et al., 1993; Klaczynski, 2001; Klaczynski & Cottrell, 2004; Morsanyi & Handley, 2008).

We investigated young children's ability to anticipate the sunk cost bias in four experiments. We tested children between 5-6-years-old, since children at this age understand that agents are willing to incur greater costs to obtain more highly valued objects (e.g., Jara-Ettinger et al., 2015). Some past experiments have examined the sunk cost bias in 'progress' decisions where people choose to continue investing resources into a failing project (e.g., Arkes & Blumer, 1985, Experiment 8; Barsky & Zyphur, 2016). Other experiments have examined the bias in 'adoption' decisions where people choose between two projects they already invested in (e.g., choosing between two purchased ski trips; Arkes & Blumer, 1985, Experiment 1; Baron et al., 1993; for a further description about this distinction, see Moon, 2001; Roth et al., 2015). Although both approaches involve choices about sunk costs, we used adoption decisions in our experiments to specifically test if sunk costs impact children's valuation of objects.

In each experiment, children were shown stories where an agent collects two identical objects, one easier to obtain and the other difficult. Experiment 1 examined which objects 5-6-year-olds and adults expected the agents to keep. Choosing the high-cost object would suggest that participants expect others to value these objects more than low-cost alternatives. Experiment 2 then compared whether 5-6-year-olds' predictions differ depending on whether they are considering sunk costs, or instead considering costs that lie in the future. Experiment 3 explored if 6-year-olds anticipate the sunk cost bias in first-person scenarios. Finally, Experiment 4

explored if 6-year-olds anticipate the sunk cost bias in first-person scenarios where the costs are incurred by other people.

## Experiment 1

### Method

**Participants.** We tested 60 children ( $M_{\text{age}} = 5;11$  [years; months], range = 5;0 – 6;10, 29 female), and 117 adults ( $M_{\text{age}} = 38$ , range = 22-72, 44 female). Data were excluded from an additional 36 adult participants who failed either one or both attention checks. These were simple questions to ensure that adults attended to the stimuli.

In this experiment, children were tested individually in child-care centers and schools in the Waterloo region (Canada). The region is predominantly middle-class, and approximately 79% of residents are White, with Chinese and South Asians as the most visible minorities. Adults were recruited from Amazon Mechanical Turk (<http://www.mturk.com/>) and were located throughout the United States and had a HIT rate of above 95%.

**Materials and Procedure.** Participants completed two trials. In each trial, they were told a story about a child who obtained two identical objects—one easy to obtain and the other difficult (see Figure 1). In the first story, a boy retrieved a rock from a deep pit and another rock from a shallow pit. In the second story, a girl retrieved a flower from a tall hill and another from a short hill. The character then learned that they could only keep one object, and children were asked which they would keep (e.g., "The boy's mom says that he can only bring one rock home. Which rock will the boy bring home?"). If participants are sensitive to sunk costs, they should choose the item that was harder to retrieve.

For children, these stories were told with corresponding pictures on a laptop. To adapt this procedure to an online format, adults read the stories with the corresponding pictures, and

answered the same test question. They then completed two four-option multiple-choice attention checks to ensure that participants read the stories and saw the pictures. In Experiments 1-3, the item that was difficult to obtain (rock in deep pit; flower on tall hill) was on the right in the first story, and on the left in the second story.

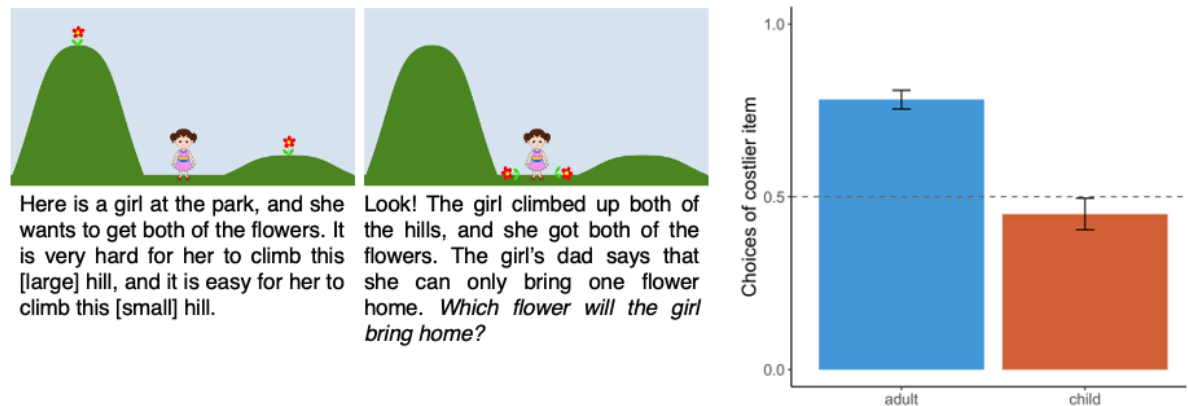


*Figure 1.* Sample story and results for Experiment 1. For all figures, the bar graph represents the proportion of choices for the costlier item, and error bars show  $\pm 1$  standard error.

## Results

In each experiment, we analyzed the results using generalized estimating equations (GEE) models (binary logistic, independent correlation matrices). The raw data from all experiments are available online at: <https://osf.io/s79re/>.

In this experiment, children's and adults' responses were analyzed in the same model, with age (child, adult) as a predictor, see Figure 1. There was a significant effect of age, Wald  $\chi^2(1) = 23.36, p < .001$ , as adults were more likely than children to choose the high-effort item. Single-sample tests were conducted using an intercept-only GEE model to examine if children and adults chose the high-effort item significantly above chance. Children's choices of the high-effort item (45% of responses) did not significantly differ from chance, Wald  $\chi^2(1) = 0.90, p =$

.342. In contrast, adults were more likely to choose the high-effort item (78% of responses) than the low-effort item, Wald  $\chi^2(1) = 34.28, p < .001$ <sup>8</sup>.

Although children's responses did not significantly differ from chance, one might wonder whether findings would differ with a larger sample. However, in this experiment and those following, supplementary single-sample Bayesian t-tests favored the null hypothesis over one holding that children appreciate sunk costs (i.e., Experiment 1,  $BF_{01} = 12.92$ ; Experiment 2,  $BF_{01} = 12.44$ ; Experiment 3,  $BF_{01} = 5.22$ ; Experiment 4,  $BF_{01} = 14.23$ ).

## Discussion

Adults anticipated the sunk cost bias, but children did not. Whereas adults predicted that each character would choose to keep the high-cost item, children's predictions did not depart from chance. In relation to previous work, these findings suggest that while children recognize that value determines willingness to incur costs (Jara-Ettinger et al., 2015), they do not believe that sunk costs influence value. This conclusion is only tentative though, as our experiment did not examine both kinds of costs.

We addressed this issue in the next experiment by including an additional between-subjects 'future cost' condition. In the scenarios in this condition, after the character collected both objects, two new ones appeared. Then, children predicted which of the two objects the character would retrieve. Previous work shows that from infancy we expect others to take the least costly path to a goal (e.g., Csibra & Gergely, 2007; Liu & Spelke, 2017). So, if children are sensitive to costs in our vignettes, they should expect the character to retrieve the low-effort object over the high-effort alternative. Additionally, we added comprehension checks to ensure

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<sup>8</sup> The results are not impacted if all adult data is retained in the analysis. There is still a significant effect of age, Wald  $\chi^2(1) = 11.96, p < .001$ , and adults were still more likely to choose the high-effort item (67%) than the low-effort item, Wald  $\chi^2(1) = 19.62, p < .001$ .

that children could accurately identify how much effort the character incurred when collecting both objects.

## Experiment 2

### Method

**Participants.** We tested a total of 60 five- to six-year-olds ( $M_{\text{age}} = 6;0$ , range = 5;0-6;11, 30 female). We aimed to test 30 children in each between-subjects condition. We were disrupted by COVID-19 and continued data collection online. The first 22 children ( $M_{\text{age}} = 6;5$ , range = 6;0-6;11, 12 female) were tested in-person at their daycares and preschools; the remaining 38 children ( $M_{\text{age}} = 5;10$ , range = 5;0-6;11, 18 female) were tested online using video conferencing software. Initially, children were not randomly assigned to a between-subjects condition as we were only testing the sunk cost condition ( $N = 13$ ). After we introduced the control condition ('future costs'), children were randomly assigned to one of the two conditions. Random assignment ceased once thirty children were tested in the sunk cost condition, so the remaining children in our sample were assigned to the future cost condition.

**Materials and Procedure.** As in Experiment 1, children first heard a story about a boy who retrieved two rocks, and a second story about a girl who retrieved two flowers (see Figure 2). In each story, one object was difficult to retrieve and the other was easy to retrieve. To ensure children were aware of this difference, each story included two comprehension questions about the effort required to obtain each item (e.g., Which hole was easy to climb into? Which hole was hard to climb into?). Two children failed these comprehension questions, but correctly responded after they were re-told the stories.

Children saw the stories in one of two between-subjects conditions. In the sunk costs condition, after each character retrieved the objects, children were told the character could only

keep one, and were asked which the character would keep. In the future costs condition, two more objects appeared. The character learned that they could only obtain one more object, and children were asked which object the character would retrieve. Hence, the character was faced with a choice between an object that would be costly to retrieve (e.g., flower on large hill) and one that would be less costly to retrieve (e.g., flower on small hill).

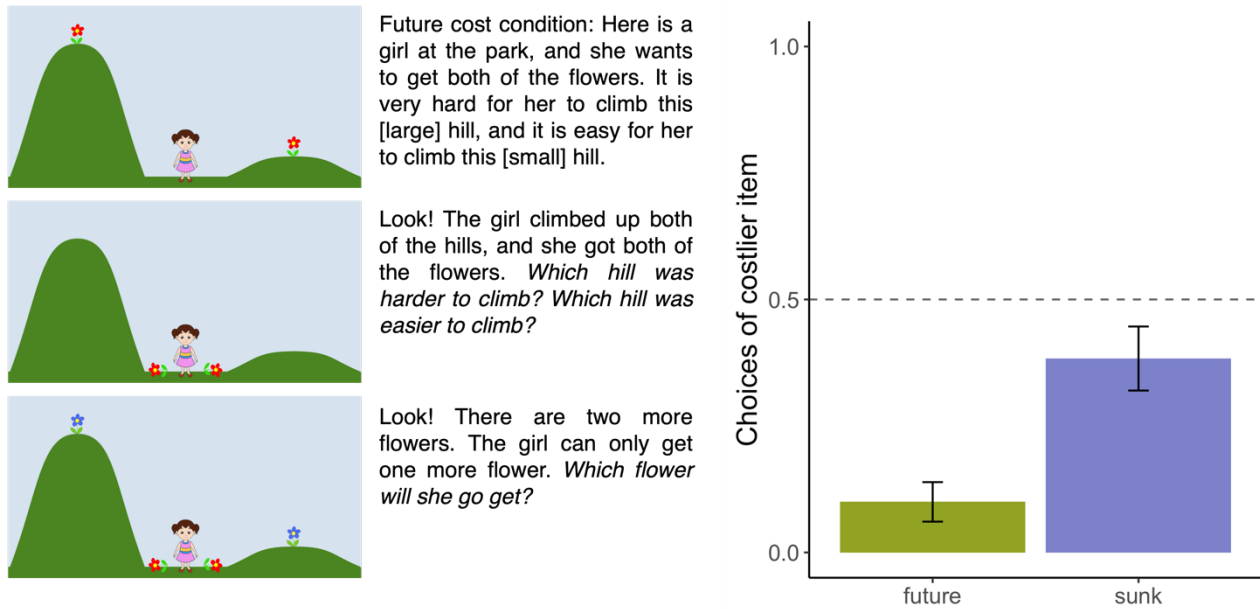


Figure 2. Sample story and results for Experiment 2.

## Results

All but two children passed both comprehension checks. After they were re-told the stories, they provided the correct answer.

A GEE model with the predictor condition (sunk cost, future cost) revealed that children were more likely to choose the high-effort item in the sunk cost than the future cost condition, Wald  $\chi^2 (1) = 9.28, p = .002$  (see Figure 2). Single-sample tests, conducted using an intercept-only GEE model, revealed that children's choices of the high-cost item in the sunk cost condition (38%) did not significantly differ from chance, Wald  $\chi^2 (1) = 2.62, p = .106$ ; whereas most

children in the future cost condition chose the low-cost item (90% of responses), Wald  $\chi^2(1) = 20.70, p < .001$ .

### **3.3. Discussion**

Children again showed no sensitivity to sunk costs, and did not anticipate that characters would value high-cost items over low-cost ones. However, children were sensitive to future costs and predicted that the character would retrieve low-effort objects. Thus, it is unlikely that children in our experiments fail to predict sunk cost choices because they do not appreciate the costs at all in this paradigm. Almost all children identified the effort associated with each object, providing further support that they can identify where greater effort was invested.

In the experiments so far, children considered third-person scenarios and predicted whether others would be sensitive to sunk costs. However, most sunk cost studies on adults have used first-person scenarios, which asked participants to predict their own hypothetical choices (e.g., Arkes, 1996; Arkes & Blumer, 1985; Frisch, 1993; Garland, 1990; Garland & Newport, 1991; Strough et al., 2008; 2014; for exceptions see Arkes & Blumer, 1985; Bornstein & Chapman, 1995; Olivola, 2018). Thus, in the next experiment we explored whether children are sensitive to sunk costs in first-person scenarios.

## **Experiment 3**

### **Method**

**Participants.** We tested 31 six-year-olds ( $M_{\text{age}} = 6;5$ , range = 6;0 – 6;11, 12 female). In the next two experiments, children were tested individually at schools and daycares in the Waterloo region (Canada).

**Materials and Procedure.** Children were tested in a single condition in which they heard two stories where they were the protagonist (see Figure 3). Before the stories began, children

were told that the stories were about them, and were instructed to imagine the stories were real. The stories were based on the sunk-cost stories from the preceding experiments, but the pictures did not show any characters. The first story described children obtaining the two rocks, and the second story described them obtaining two flowers. The stories, including the comprehension and test questions, were all in second-person (i.e., “*Your* teacher says that *you* can only bring one rock home. Which rock will *you* bring home?”). All children passed the comprehension questions.

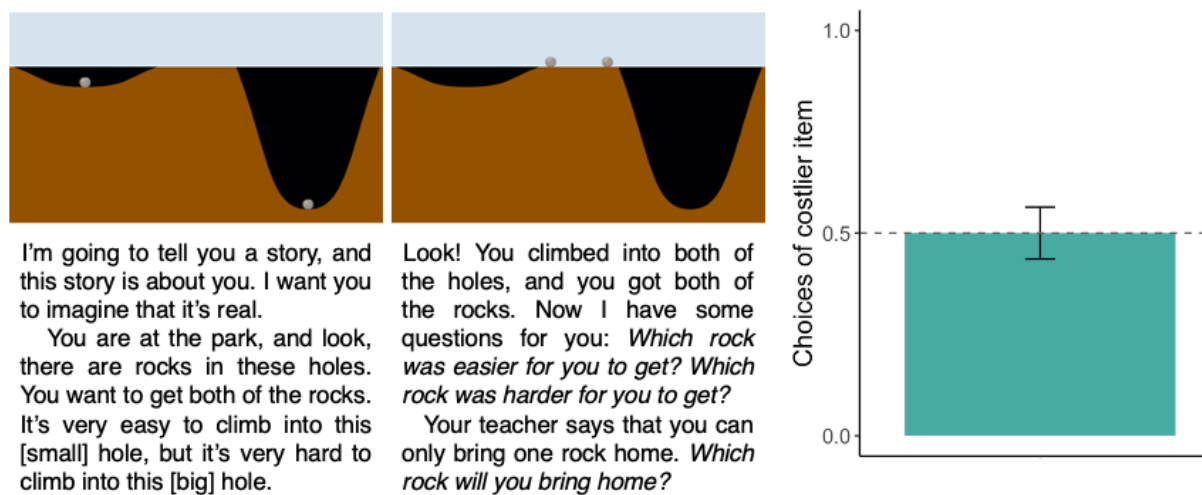


Figure 3. Sample story and results for Experiment 3.

## Results

All children passed the comprehension questions. An intercept-only GEE revealed that children's choices of the high-cost item (50% of responses) did not significantly differ from chance, Wald  $\chi^2(1) = 0.00, p > .999$  (see Figure 3).

## Discussion

As in the previous experiments, children were not sensitive to sunk costs. This shows that the findings from our first two experiments replicate even when children respond to first-person

scenarios. In our final experiment, we explored a further factor known to affect sunk cost judgments in adults. Past research has mostly examined intrapersonal sunk costs where a person's valuation of an object depends on costs *they* have sunk. However, adults are also sensitive to sunk costs in interpersonal contexts, where costs are sunk by *others*. For instance, in one study, adults were told that two friends had each purchased a trip for them on the same day, one that was cheaper and more enjoyable, and the other expensive and less enjoyable (Olivola, 2018). Adults were more likely to choose the less enjoyable trip when it was more expensive, rather when it was cheaper, suggesting they were sensitive to others' sunk costs in their own choices.

## Experiment 4

### Method

**Participants.** We tested 34 six-year-olds ( $M_{\text{age}} = 6;7$ , range = 6;0 – 6;11, 18 female).

**Materials and Procedure.** Children were told two stories (see Figure 4). In both stories, two characters collected objects (shells in story 1, rocks in story 2), and children were told the objects were for them. One of the characters worked harder to collect their item than the other character. Children decided which of the two objects they would keep.

Characters were described from left to right in each story. The location of the low- and high-effort characters were counterbalanced across stories (i.e., left character in first story and right character in second story), and across children (i.e. left character in first story or right character in first story).

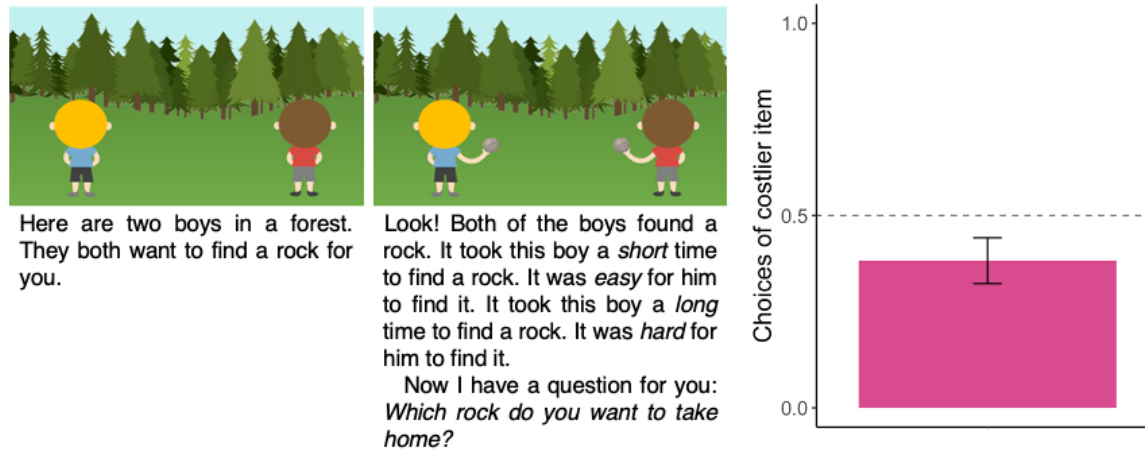


Figure 4. Sample story and results for Experiment 4. Error bar shows  $\pm 1$  standard error.

## Results

An intercept-only GEE revealed that children's choices of the high-cost item (38% of responses) did not significantly differ from chance, Wald  $\chi^2(1) = 3.27, p = .070$  (see Figure 4).

## Discussion

We again found that children did not appreciate sunk costs. Children had no clear preference for which object they would keep, indicating that they may be insensitive to others' sunk costs.

## General Discussion

Across four experiments, children were insensitive to sunk costs. For example, children expected that a girl would be no more likely to choose a flower that was difficult to obtain than a flower that was easily obtained, though adults expected the girl to choose the high-cost flower. Children also were not sensitive to sunk costs when they chose between the objects themselves, or when they chose between objects that others collected for them. However, children anticipated that others would minimize costs when obtaining objects. For instance, they anticipated that a

girl would be more likely to retrieve a flower from a small hill that was easy to climb, than from a larger one that would require more effort. Together these results show that although children are sensitive to future costs, they do not expect sunk costs to influence decision making.

Our findings suggest an asymmetry in how young children consider costs when understanding others' actions. The findings from our 'future cost' condition join recent work in showing that children expect an agent's valuations and preferences to determine the costs the agent is willing to incur to obtain objects (Jara-Ettinger et al., 2015; 2016; 2020). Specifically, we found that when offered two identical rewards, children predicted an agent would pursue the one that would be less costly to obtain. Likewise, previous work shows that when potential rewards differ from one another, young children understand that agents will incur greater costs for the reward they prefer (Jara-Ettinger et al., 2017). However, our experiments also suggest that children do not expect the opposite relation to be true. They do not expect agents' valuations and preferences for objects to depend on the costs incurred to obtain them.

The present work also suggests that young children may struggle to understand and predict irrational behavior. The sunk cost bias is considered irrational, since choosing the high-cost object will not recover or justify the effort spent pursuing it (Arkes, 1996; Arkes & Ayton, 1999; Arkes & Blumer, 1985; Thaler, 1980). In our experiments, adults anticipated this irrational behavior, but children did not. This finding is consistent with recent work suggesting that 5-6-year-olds have difficulty understanding that habitual behavior can lead to suboptimal actions, but understand this by age 7 (Goldwater et al., 2020). It is possible that both findings (i.e., our sunk cost findings, and young children's difficulty anticipating nonoptimal habitual behaviors) arise because young children expect others to behave rationally in light of their beliefs and desires,

and environmental constraints (e.g., Gergely & Csibra, 2003; Leslie et al., 2005; Jara-Ettinger et al., 2016).

However, this account may not explain why children were insensitive to sunk costs in the final experiment, where children chose between objects that others expended time and effort to obtain. In interpersonal sunk cost scenarios, respecting sunk costs might be considered *rational* (i.e., rather than irrational as in regular intrapersonal scenarios). Rejecting the high-cost object in favor of the low-cost one would likely offend the friend who invested more, so it is arguably rational to consider sunk costs in this situation. This proposal is consistent with findings that people expect others to appreciate expensive gifts more than inexpensive ones (Flynn & Adams, 2009; Zhang & Epley, 2012). Future work needs to be conducted to confirm this speculation by further examining children and adults' interpersonal choices.

Children's insensitivity to sunk costs could also stem from their conceptions of waste. Adults may feel that choosing a high-cost object prevents wasting the cost that was sunk to obtain it (Arkes, 1996; Arkes & Ayton, 1999; Arkes & Blumer, 1985; Bornstein & Chapman, 1995). For example, adults might have felt that if the girl chose the flower from the small hill, the cost she incurred in climbing the big hill would all be for nothing. However, children might not have viewed the costs as going to waste. This account could explain why children in our third experiment, and in previous work (e.g., Morsanyi & Handley, 2008), did not show the sunk cost bias themselves. If children do not view sunk costs as wasted, then this might not only prevent them from anticipating it in others, but also prevent them from being susceptible to the bias in their own choices.

The key claim of this account is that children might not view sunk costs as wasted. This account does not claim that children are oblivious to waste, and indeed some recent work shows

that young children do have some aversion to waste. For example, 6-8-year-olds are less willing to throw away valuable resources than cheaper ones when avoiding inequitable allocation of resources (Choshen-Hillel et al., 2020), suggesting that young children are sensitive to waste (see Rossano et al., 2011 for evidence of 3-year-olds' negative response to throwing away resources). However, children might have difficulty viewing time and effort as going to waste in sunk cost situations.

Other accounts might also explain why children did not share adults' sensitivity to sunk costs. For example, adults may have reasoned that if a character incurred high costs to obtain an object, it must have been initially more valuable to the character. Children by contrast might not have drawn this inference—they might believe that identical-looking objects are always similarly valued. We doubt this account for two reasons but acknowledge that future work will be needed for definitive answers. First, it is unlikely that adults thought the character preferred one object from the outset, as the character collected both objects before discovering they could only keep one. Second, previous findings show that young children do recognize that identical-looking objects can be valued differently. Children value objects they make over identical-looking objects (Marsh et al., 2018; also see Li et al., 2013), and also value objects with distinctive histories over identical ones with mundane histories (Frazier & Gelman, 2009; Gelman et al., 2015; Hood & Bloom, 2008; Pesowski & Friedman, 2019; for a review, see Gelman & Echelbarger, 2019).

To conclude, our findings suggest that young children expect future costs, but not sunk costs, to influence decision-making. These findings are suggestive of an asymmetry in how children view the relation between costs and valuation of objects. Together, this work advances our knowledge of how children reason about sunk costs, and their ability to predict irrational actions in general.

## Chapter Three

### Emotions Before Actions: When Children See Costs as Causal

A version of this paper is published:

Sehl, C. G., Friedman, O., & Denison, S. (2024). Emotions before actions: When children see costs as causal. *Cognition*, 247, 105774.

When people invest time, money, or effort into a project, they tend to overvalue it. For example, imagine you have two identical frozen dinners—you bought one on sale and the other at full price. Your freezer breaks, causing the dinners to defrost. You can only eat one dinner, the other will have to be thrown out. Which dinner will you eat? You might choose the full-priced dinner because you do not want to waste the money spent on it. That is, you might show the sunk cost bias—the tendency to find items or projects more valuable when you have invested more into them (Arkes, 1996; Arkes & Ayton, 1999; Arkes & Blumer, 1985; Bornstein & Chapman, 1995). Making choices in this way is irrational (e.g., Arkes & Blumer, 1985; Thaler, 1980). While choosing the full-priced meal might seem to avoid wasting money, the money cannot be recouped regardless of which meal is chosen.

Aside from influencing your decision of which dinner to eat, sunk costs may also influence how you feel. Buying an extra meal feels wasteful and you might especially regret or feel upset about having bought the full-price meal (Arkes, 1996; Dijkstra & Hong, 2019; for other work on affect and sunk costs, see Coleman, 2010; Hafenbrack et al., 2014; van Putten et al., 2010). While basing decisions on sunk costs is irrational, feeling frustrated about them, or regretting them, may not be irrational (for a discussion, see Baron, 1985; Zeelenberg, 1999). It could even be adaptive for people to feel greater disappointment or regretful about sunk costs, as these emotions could help people make better decisions in the future (e.g., being careful not to buy more dinners than necessary; Zeelenberg, 1999).

Here, we investigate whether young children predict people’s decisions and emotions based on sunk costs. Previous work has shown that 5-6-year-olds do not expect decisions to be biased by sunk costs. In a series of experiments, children and adults watched sunk cost scenarios. For example, in one scenario, a girl could keep one of two identical flowers she had collected—a ‘high cost’ flower from a tall hill that was hard for her to climb, or a ‘low cost’ flower from a short hill that was easy for her to climb. While adults predicted she would be biased by sunk costs and keep the high-cost flower, children chose between the flowers at chance (Sehl et al., 2021). Other studies have also found that children aged 5-12 do not anticipate the sunk cost bias (Baron et al., 1993; Morsanyi & Handley, 2008; Webley & Plaisier, 1998). However, some studies report that older children aged 8-12 years anticipate the sunk cost bias in choices involving whether to persist in a course of action (Klaczynski, 2001; Klaczynski & Cottrell, 2004).<sup>9</sup>

Young children’s failure to anticipate that sunk costs bias actions might seem to conflict with findings showing that preschool-aged children make sophisticated inferences about costs (e.g., Aboody et al., 2021; Ahl et al., 2023; Bridgers et al., 2020; Sommerville et al., 2018; Zhao & Kushnir, 2023). From as young as age five, children infer an agent’s preference for an object by considering the costs required to obtain it (Jara-Ettinger et al., 2015; 2016; Pesowski et al., 2016; see also Amemiya et al., 2022; 2023). Further, children and even infants, expect agents to pursue goals while minimizing costs (Gönül & Paulus, 2021; Sehl et al., 2021; see also Gergely & Csibra, 2003; Gergely et al., 1995; Liu & Spelke, 2017; Schuwerk & Paulus, 2016). However, these two lines of work do not conflict. The work on children’s understanding of costs centers on the idea that agents’ preferences affect their willingness to incur costs. But sunk cost predictions

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<sup>9</sup> These studies on older children do not provide decisive evidence for the sunk cost bias. For instance, in one study, persisting towards a goal was also the course of action that required the least effort in the future (Klaczynski & Cottrell, 2004).

reverse this inference, and instead involve seeing incurred costs as determining agents' preferences.

Why do children overlook the sunk cost bias? One explanation—suggested by the idea that children see incurred costs as resulting from preferences, but not as affecting them— is that children see costs as having a limited causal role. They recognize that incurring costs can secure a desired outcome, but might not see incurring costs as having other consequences. On this account, once the costs have been incurred (i.e., once they are sunk), children see them as having no further causal relevance. If so, children might also neglect other effects of sunk costs, such as sunk costs leading to emotions like regret or sadness. A related explanation is that children might not *tag* sought-after items with the costs incurred to obtain them. For example, they might not see one flower as the “high cost” item and the other as the “low cost” item. If children do not tag the flowers with their costs, children should view them as equivalent when predicting which one the girl will keep. On this tagging account, children lack abilities requisite for mental accounting—they do not segregate costs into different mental “accounts” (Baron, 2008; Thaler, 1999; as also suggested by Krouse, 1986; Webley & Plaisier, 1998). Work on children’s valuation of objects shows that with age, children increasingly tag objects in terms of their histories (for reviews see Pesowski et al., 2022; Gelman & Echelbarger, 2019). For example, whereas children aged 4-5 recognize that objects are more valued if they once belonged to famous individuals, it is not until age 11 that children recognize the heightened value of original creations (Gelman et al., 2015). It is less clear whether children tag objects with the effort invested in obtaining them. Children around age 5 prefer objects they built over identical alternatives (Marsh et al., 2018; see also Marsh et al., 2022), and other findings suggest children’s own effort pursuing goals affects

their valuations (Benozio & Diesendruck, 2015; also see Katz et al., 2024). But almost no work has looked at third person valuations.

On another account, children overlook the sunk cost bias because they do not think future actions can make up for sunk costs. Whereas adults see eating the full-price dinner and keeping the high-cost flower as avoiding a major loss of spent money and effort, children may not share this view. On this account, children may still see incurred costs as causally relevant for emotions—they may anticipate that incurring costs can lead people to feel sad or regretful. Finding that children consider sunk costs as causally relevant for emotions would suggest that children are not entirely insensitive to sunk costs as we may have previously thought.

We tested between these accounts in three experiments. In each experiment, participants saw stories about characters who collected items that were easy and difficult to obtain. In Experiment 1, we first tested whether 4-7-year-olds use sunk costs to infer others' emotions. In Experiment 2, we again tested whether children used sunk costs to infer emotions and also whether they use sunk costs to infer actions. As a point of comparison, we also examined these questions with a sample of adult participants. In Experiment 3, we replicated children's and adults' emotion predictions with different vignettes and contrasted it with another action prediction.

### **General Method**

All experiments but Experiment 1 were preregistered. The preregistrations, materials, data, and code are available online at <https://osf.io/mvf87/>.

We tested children in all three experiments. Most children were tested in person (total  $N = 226$ ), but some were tested online (total  $N = 94$ ). In both cases, the experimenter narrated the scenarios and questions about them. For in-person testing, children were shown pictures

individually on a laptop at local schools and a museum in the Waterloo region (Canada). Demographic information was not formally collected, but the region is predominantly middle-class, and approximately 79% of residents are White, with Chinese and South Asians as the most visible minorities. For online testing, children were tested individually in a live video call, in the presence of their parent or guardian. Parents were instructed to look down or to turn away from the screen while testing took place. Children answered test questions by identifying the color of clothes the characters were wearing (Experiment 1) or the color box that highlighted the items (Experiments 2 & 3). Before completing the test trials, children were asked two comprehension questions about where it was easy and difficult to obtain the items. We excluded children who failed any of the three comprehension checks three times in a row. In Experiments 1-2, comprehension questions were asked after the initial vignette, and in Experiment 3 they were asked before both test trials.

In Experiments 2 and 3 we also tested adults recruited from CloudResearch (Litman et al., 2017). They were located throughout the United States and were required to have completed at least 100 HITs with a 95% acceptance rate. They completed the experiments over Qualtrics and so they read the stories and questions. Adults answered post-test attention checks to ensure they read the stories (three questions in Experiment 2, two questions in Experiment 3). We excluded adults who neglected to answer the test trials or failed at least one of the post-test multiple-choice attention checks.

## Experiment 1

### Method

**Participants.** We tested 80 four- to seven-year-olds ( $M_{age} = 5;11$  [years;months], range = 4;0-7;11, 35 female, 45 male; 20 children per age in years). One additional 4-year-old was excluded for not answering comprehension questions correctly.

**Procedure.** Children saw pictures of two characters each standing beside a bookshelf and heard a story about the characters collecting toys from them (see Figure 5). In each trial, one of the toys was lower on a bookshelf and the other was higher on a bookshelf, and characters each collected the toy from their respective bookshelf. The characters then learned that the toys were broken, and children were asked which character was sadder.

In one within-subjects condition, the characters were short, so it was easy to retrieve toys on low shelves and difficult to retrieve toys on high shelves. In the other condition, the characters were tall, so the opposite was true. Children completed a total of four trials; two trials in each condition. Trials within each condition were shown in a fixed order: The short characters first obtained cars (higher one on left), and then boats in the second trial (higher one on right); the tall characters first obtained jack-in-the-boxes (higher one on left), and beach balls in the second trial (higher one on right).



Figure 5. Sample stimuli and script in Experiment 1.

## Results

In all experiments, we analyzed the results using generalized estimating equation models (GEE; binary logistic, independent correlation matrix). Age in months (mean-centered) was entered as a covariate, with condition as a within-subjects factor. There was a main effect of condition, as children were more likely to select the child who retrieved the toy from the higher shelf in the short character trials than the tall character trials,  $F(1) = 30.56, p < .001$ , see Figure 6. There was no main effect of age,  $F(1) = 0.62, p = .432$ , but there was a significant interaction between trial type and age,  $F(1) = 20.12, p < .001$ . This interaction resulted because for the short character trials, children were more likely to select the character who retrieved the toy from the higher shelf as they got older,  $p < .001$ . For the tall character trials, children were more likely to select the character who retrieved the toy from the lower shelf as they got older,  $p = .015$ .

To pinpoint the age where responses in the short character and tall character trials first diverged, we examined when their 95% confidence intervals no longer overlapped.<sup>10</sup> This was at age 5;5; short character judgment,  $CI_{95\%} [0.53, 0.73]$ ; tall character judgment  $CI_{95\%} [0.34, 0.51]$ . The confidence intervals also show that responses in the short character trials first went above chance (toward the tall shelf) at 5;4,  $CI_{95\%} [0.52, 0.72]$ , and responses in the tall character trials first fell below chance (toward the low shelf) at 5;8,  $CI_{95\%} [0.29, 0.49]$ .

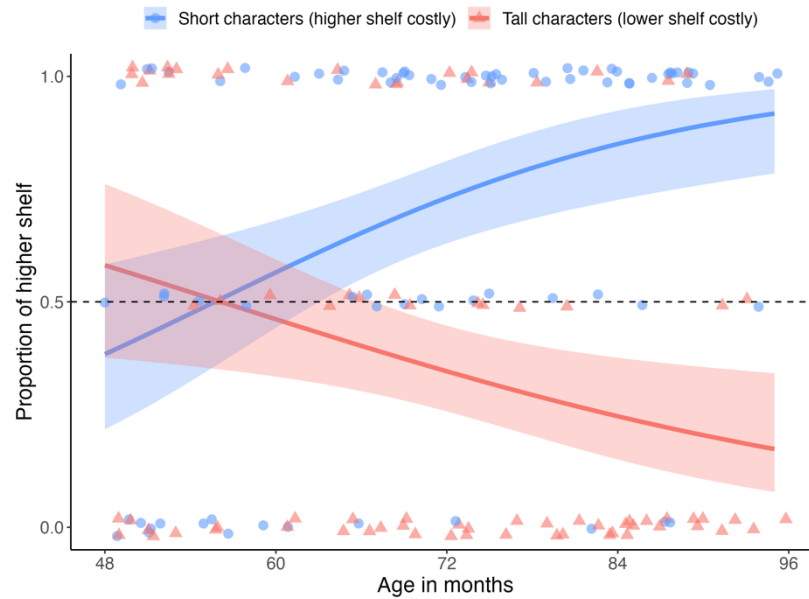


*Figure 6.* Results of Experiment 1, showing the proportion of children’s selection of the character with the higher shelf as a function of trial type and age. In all graphs, colored bands and error bars show 95% confidence intervals, and points are jittered to avoid overplotting.

## Discussion

We found that around age five, children considered others’ sunk costs to infer emotion. They judged that the character who exerted more effort towards a failed goal would be sadder than a character who exerted less effort. Children inferred this for short and tall trials, suggesting that they did not simply associate greater sadness with a character who obtained their toy from a

<sup>10</sup> This approach provides a conservative estimate for the age in which responses in each condition differ and when responses differ from chance (for use of this approach, see Blake et al., 2015; see also Corbit, 2020; Lee & Warneken, 2020). This approach is considered conservative because it is possible to have significant p-values when CIs overlap (Greenland et al., 2016).

larger shelf—that is, their responses did not reflect “more-is-more” reasoning (see Stavy et al., 2002). Instead, children predicted that the character who exerted greater effort towards collecting their toy would be sadder.

These findings suggest that while children do not use sunk costs to predict actions (e.g., Sehl et al., 2021), they can use sunk costs to predict emotions. If so, this would support the account which predicts that children consider sunk costs as causal. However, this finding is inconsistent with the account claiming that children see costs as non-causal, and as incapable of affecting both emotions and actions. To be more certain about this conclusion, though, in the next experiment we compared predictions of emotions and actions in a single experiment. As an extra precaution, the next experiment also included a sample of adults. For reasons discussed below, we wanted to be sure they would predict that actions would be biased by sunk costs.

One concern with the present experiment is that children might have identified the high-cost character as sadder, without thinking that incurring greater costs caused the character to be sadder. Instead, children may have inferred the value each character placed on their toy. They could have assumed that the character who worked harder would like their toy more and thus be sadder if it broke. To address this concern, the next experiment used stories where one character collected identical objects, instead of two separate characters each collecting an object. This design avoids this alternative explanation because it is unlikely that a character would initially value one toy over an identical one.

## **Experiment 2**

In this experiment, participants watched a boy collect two toys that he later discovered were broken. Participants were either asked about his emotions (“Which [toy] is the boy more sad about?”) or his actions (“Which [toy] will the boy fix?”). We asked about fixing the broken

toy because this action fits with the idea that sinking costs in a goal increases people's tendency to pursue it (e.g., Arkes & Blumer, 1985; Bornstein & Chapman, 1995). However, because we do not know of previous experiments to use this measure, we included an adult sample to be sure this action judgment would produce sunk cost predictions.

## Method

**Participants.** We tested 120 five- to seven-year-olds ( $M_{age} = 6;5$ , range = 5;0-7;11, 73 female, 47 male; 40 children per age in years) and 217 adults ( $M_{age} = 39.22$ , range = 22-76, 76 female, 137 male, 4 other/unspecified). An additional 14 children and 22 adults were tested but excluded due to our preregistered exclusion criteria.<sup>11</sup>

**Procedure.** Participants saw pictures of a boy standing beside two bookshelves and heard a story about him collecting toys from them (see Figure 7). The boy retrieved a toy from up high on one bookshelf, and one low down on the other bookshelf. The boy was short so it was easier to retrieve toys from lower shelves. In each of four trials, participants saw that the boy collected both toys, and were either asked which toy the boy was sadder about, or which toy the boy would fix (between-subjects).

Before completing test trials, participants were informed that the boy could take the toys home and keep them forever. After, children were asked an additional comprehension question about how long the boy could keep the toys. The test trials were shown in a fixed order: cars (higher one on left), boats (higher one on right), jack-in-the-boxes (higher one on right), beach balls (higher one on left).

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<sup>11</sup> All excluded children passed our second and third questions, but failed the first one, "How long does the boy get to keep the toys". The correct answer was "forever" (though we also accepted variations of this, e.g., "a long time", "100 days", etc.) but many children failed with answers like "a few minutes" or "for the day". Regardless, when data from the excluded children are retained in the analysis, the results come out the same (see Appendix A for the analysis and plot).

To explore whether asking about the boy's sadness impacts children's response to the fix judgment, we asked children which toy the boy would fix after the last trial in the sadness condition. We discuss the results in Appendix A.

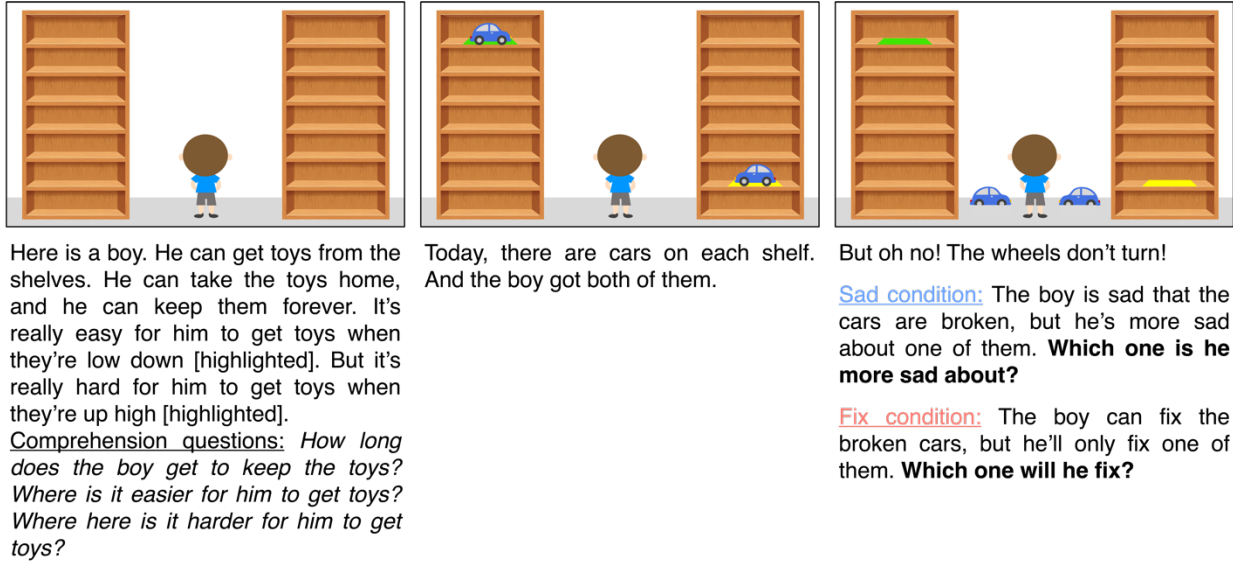


Figure 7. Sample stimuli and script for Experiment 2.

## Results

Figure 8 shows children's and adults' sad and fix judgments. We first ran separate analyses on children and adults, but also report an exploratory analysis comparing their responses.

**Children.** There was a main effect of condition, as children were more likely to select the high-cost toy when judging which toy the boy was sadder about than which one the boy would fix,  $F(1) = 44.74, p < .001$ . There was also a main effect of age, as children were more likely to select the high-cost boy with age,  $F(1) = 4.12, p = .043$ . There was a significant interaction between condition and age,  $F(1) = 6.18, p = .013$ .

To follow-up on this interaction, we separately examined responses in each condition. In the sad condition, there was no effect of age,  $p = .727$ , with children mostly predicting the boy

would be sadder about the high-cost toy,  $CI_{95\%} [0.61, 0.76]$ . By contrast, in the fix condition, older children were more likely than younger ones to predict the boy will fix the low-cost toy,  $p = .003$ , and responses first fell below chance (toward the low-cost toy) at 5;8,  $CI_{95\%} [0.31, 0.48]$ . Responses in the sad and fix conditions first diverged at age 5;5; sad judgment,  $CI_{95\%} [0.57, 0.76]$ ; fix judgment  $CI_{95\%} [0.34, 0.54]$ .

**Adults.** There was a main effect of condition, as adults were more likely to select the high-cost toy in the sad condition than the fix condition,  $F(1) = 38.18, p < .001$ , see Figure 8. Adults mostly predicted the boy would be sadder about the high-cost toy,  $p < .001, CI_{95\%} [0.79, 0.91]$ , but only indicated it at chance when predicting which toy he would fix,  $p = .641, CI_{95\%} [0.39, 0.57]$ .

**Exploratory analysis.** We compared children's and adults' responses using a binary logistic GEE with age (child, adult) and condition (sad, fix) as predictors. There was a main effect of condition, as participants were more likely to select the high-cost toy in the sad condition than the fix condition,  $F(1) = 82.17, p < .001$ . There was also a main effect of age, as adults were more likely to select the high-cost toy than children,  $F(1) = 21.76, p < .001$ . There was no interaction between condition and age,  $F(1) = 0.27, p = .602$ .

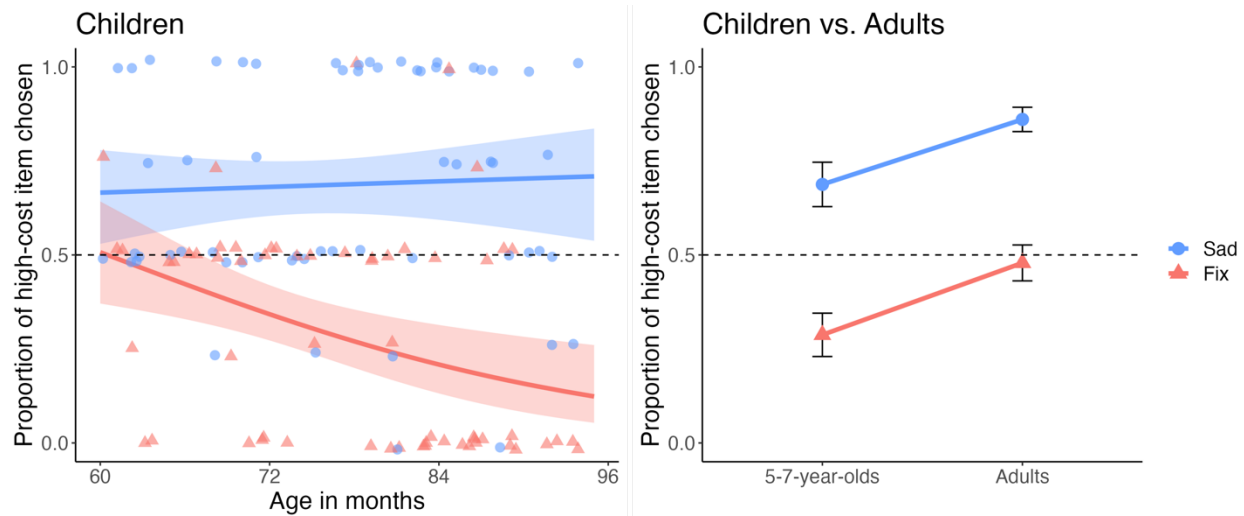


*Figure 8.* Results for Experiment 2. The left graph shows children’s responses in the sad and fix conditions by age. The right graph provides a comparison between children’s and adults’ responses across conditions.

## Discussion

Children at all ages and adults predicted that characters would be sadder about high-cost toys than low-cost ones. These findings again suggest that children use sunk costs to predict emotions. Further, these results suggest that children’s sadness judgments in Experiment 1 were not merely driven by the inference that the high-cost character initially valued their toy more than the low-cost character.

However, neither children nor adults inferred that the character would fix the high-cost toy. These findings raise the question of whether adults saw the scenario as involving sunk costs. If they did not, this might explain why adults didn’t expect the boy to honor sunk costs when deciding which toy to fix. To address this question, we showed adults the same scenarios (plus versions where the toys were not broken) and asked them which toy the boy would keep and which he would play with (see Appendix A). Adults predicted the boy would choose the high-cost objects,  $p < .001$ . This finding shows that adults *did* see the situation as involving sunk costs, and likewise suggests that fix judgments are less susceptible to sunk cost effects. An

explanation for this comes from work showing that adults are less likely to predict others will be biased by sunk costs when the future investment is greater than the sunk costs (Thames, 1996; see also Arkes & Blumer, 1965; Garland, 1990; Olivola, 2018). That is, adults may have thought that fixing the toys would require greater effort compared to acquiring them initially, making the (sunk) costs of obtaining the toys appear trivial in comparison to the future cost of repairing them.

Returning to children, what do the findings tell us about how they see sunk costs? Again, the findings suggest children use sunk costs to predict emotions. But given the adult findings, we cannot conclude much from their fix judgments. It's also difficult to understand why younger children chose between the toys at chance whereas older children predicted the character would fix the low-cost toy. One explanation is that this effect was driven by children's experiences with fixing broken things. Whereas younger children likely have little experience with this, older children might recognize that fixing takes time and effort and might have preferred to invest further effort into the toy that had seen less prior investment (i.e., a kind of reverse sunk cost effect). Admittedly, this explanation is speculative and entirely post hoc (i.e., we never would have predicted the developmental trend) and it also does not explain why adults' fix judgments more closely resemble those of the younger children.

### **Experiment 3**

In the final experiment, we again compared how children and adults use sunk costs to infer emotion and action. But rather than asking about fixing items, we instead asked participants to judge which of two items a character would keep, since this measure has been used in previous work on adults' sunk cost predictions (Arkes & Blumer, 1985; Baron et al., 1993; Sehl et al., 2021).

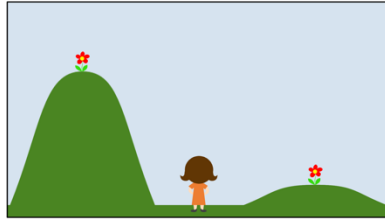
## Method

**Participants.** We tested 120 five- to seven-year-olds ( $M_{age} = 6;6$ , range = 5;0-7;11, 62 female, 58 male; 40 children per age in years) and 212 adults ( $M_{age} = 41.29$ , range = 21-72, 102 female, 109 male, 1 other/unspecified). All children answered the comprehension questions correctly, so none were excluded. Data were excluded from an additional 23 adults who failed the first post-test multiple-choice comprehension check.<sup>12</sup>

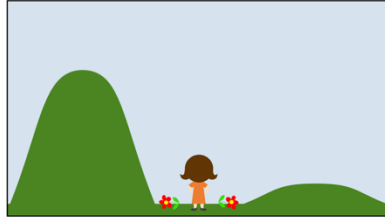
**Procedure.** Participants saw two stories about a character who collected two identical items (see Figure 9). One was easy for them to obtain (e.g., a flower from a short hill) and the other was difficult for them to obtain (e.g., a flower from a tall hill). After the character collected both items, they learned that they were not allowed to keep both of them. In one between-subjects condition, participants were asked which item the character was sadder about; for example, “the girl is sad that she can’t keep both of the flowers, but she’s more sad about one of them. Which one is she more sad about?”. In the other condition, participants were asked which item the character would keep; for example, “the girl cannot keep both flowers, but she can keep one of them. Which one will she keep?”. The location of the high-cost item was on the right in the first story, and on the left in the second story.

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<sup>12</sup> We also preregistered that we would exclude participants if they failed the second comprehension check. However, this question had a response option that was easily confused with the correct answer. Using this exclusion criterion would remove an additional 58 participants, so we included their responses in our analyses. However, excluding responses from these participants does not impact the results.



Here is a girl at the park, and she wants to get both of the flowers. It's very hard for her to climb the big hill, and it's very easy for her to climb the small hill.



And look! The girl climbed up both of the hills, and she got both of the flowers.

Comprehension questions: Which hill was harder for her to climb? Which hill was easier for her to climb?

The girl's dad says that she can't keep both of the flowers.

Sad condition: The girl is sad she can't keep both of the flowers, but she's more sad about one of them. **Which one is she more sad about?**

Keep condition: The girl can't keep both of the flowers, but she can keep one of them. **Which one will she keep?**

Figure 9. Sample stimuli and script for Experiment 3.

## Results

Figure 10 shows children's and adults' sad and keep judgments. As before, we first ran separate analyses on children and adults, and then ran an exploratory analysis comparing their responses.

**Children.** There was a main effect of condition, as children were more likely to select the high-cost item in the sad condition than the keep condition,  $F(1) = 18.99, p < .001$ . There was no main effect of age,  $F(1) = 1.81, p = .179$ , and no interaction between condition and age,  $F(1) = 0.02, p = .896$ . Single-sample tests against chance revealed that children mostly chose the high-cost item in the sad condition,  $p < .001$ ,  $CI_{95\%} [0.73, 0.89]$ , but children's responses did not differ from chance in the keep condition,  $p > .999$ ,  $CI_{95\%} [0.40, 0.60]$ .

**Adults.** There was a main effect of condition, as adults were more likely to select the high-cost item in the sad condition than the keep condition,  $F(1) = 3.91, p = .048$ . However, in both conditions, adults mostly indicated the high-cost item; sad condition,  $p < .001$ ,  $CI_{95\%} [0.92, 0.99]$ , keep condition,  $p < .001$ ,  $CI_{95\%} [0.84, 0.95]$ .

**Exploratory analysis.** There was a main effect of condition, as participants were more likely to select the high-cost item in the sad condition than the keep condition,  $F(1) = 18.26, p < .001$ . There was also a main effect of age, as adults were more likely to select the high-cost item than children,  $F(1) = 42.46, p < .001$ . There was an interaction between condition and age,  $F(1) = 4.04, p = .044$ . This interaction resulted because there was a greater effect of age in the keep condition than the sad condition; keep  $M_{diff} = 0.38, p < .001$ ; sad  $M_{diff} = 0.11, p = .004$ .

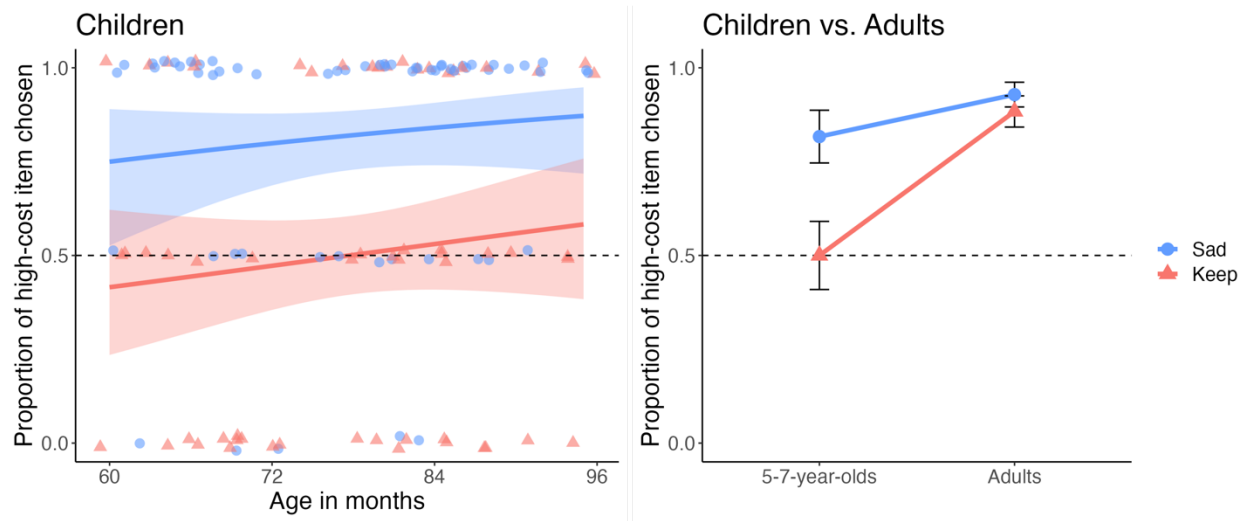


*Figure 10.* Results for Experiment 3. The left graph shows children's responses in the sad and keep conditions by age. The right graph provides a comparison between children's and adults' responses across conditions.

## Discussion

We found further evidence that as early as age 5, children use sunk costs to infer emotions. However, while adults predicted that the character would keep the high-cost item, 5-7-year-olds chose between objects at chance.

## General Discussion

Young children and adults used sunk costs to infer others' emotions. They expected that characters would be more upset about broken toys that were harder to get, and more upset about

leaving behind items they worked harder to collect. However, only adults used sunk costs to infer action (an exception is Experiment 2, which we discuss below). While adults expected characters would keep high-cost items, children chose between high-cost and low-cost items at chance. Overall, these results suggest a developmental lag. While children understand how sunk costs can affect emotions, it is only later that people think others will honor sunk costs.<sup>13</sup>

Our findings show that incurred costs are also integrated into children's and adults' theory of emotions (e.g., Harris, 2008; Ong et al., 2015; Saxe & Houlihan, 2017, Walle & Lopez, 2020; Wellman & Banerjee, 1991). Some prior work hinted that adults link emotions with sunk costs (e.g., Dijkstra & Hong, 2019; Wong & Kwong, 2007; Zeelenberg & Van Dijk, 1997). For example, one study found that people often discuss negative emotion when justifying why they think others will be biased by sunk costs (Arkes, 1996). But none of this work directly showed that adults expect sunk costs to cause negative emotions. Also, while developmental work has investigated if children and adolescents use sunk costs to predict actions, this work did not look at emotion predictions (e.g., Baron et al., 1993; Morsanyi & Handley, 2008; Sehl et al., 2021; Webley & Plaisier, 1998). The connection between costs and emotions was also not explored in work examining how children infer emotions (e.g., Hadwin & Perner, 1991; Harris et al., 1989; Lagattuta, 2005) and reason about costs (e.g., Jara-Ettinger et al., 2016; Powell, 2022).

Our findings are informative about why children fail to anticipate that sunk costs bias actions. One explanation we considered is that children see sunk costs as effects, but not as causes. But contrary to this account, we found that children recognize that incurring costs does affect people's emotions. A related account is that children overlook sunk costs because they do

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<sup>13</sup> The second experiment also included an anomalous finding: Adults did not predict characters would honor sunk costs when deciding which toy to fix. As discussed above, this likely resulted because of considerations specific to the question about fixing, given further findings that adults expected sunk costs to be honored in decisions about which object to play with and keep (see Appendix A).

not tag objects with the effort invested to obtain them. Again, children's emotion inferences speak against this. Children must have tracked which flower was high-cost and low-cost in order to infer that the girl would be sadder about the flower from the tall hill. So, children tag objects with their costs, just as they tag them with other aspects of their histories (Pesowski et al., 2022; Gelman & Echelbarger, 2019).

A more promising explanation relates to potential differences between how mental accounting works in children and adults. In mental accounting, adults see actions as existing on an internal balance sheet (Thaler, 1985, 1999). For example, getting a reward with little effort is profitable, whereas spending a lot of effort on a meager reward may only count as breaking even or as a loss. Adults also often see these transactions as occurring in separate accounts—instead of looking at the net balance across all actions, they look at them in isolation. So, when the girl learns she can keep only one flower, adults see her as faced with either a small loss for the low-cost flower or a greater loss for the high-cost one. To minimize losses, adults predict she will choose the high-cost flower.

Children may complete some but not all aspects of mental accounting. Children's emotion inferences suggest that they treated actions as existing in separate accounts (c.f., Baron, 2008; Krouse, 1986; Thaler, 1999; Webley & Plaisier, 1998). After all, if children did not do this (i.e., if they had not separately tagged objects with the effort required to obtain them), they should have viewed the girl as equally sad about them. However, children may not retrospectively calculate the balance of each account by considering sunk costs relative to rewards. So, although children recognize that the flower from the tall hill represents a greater

loss, they do not see keeping that flower as offsetting this loss. Put another way, whereas adults see sunk costs as recoupable, children do not.<sup>14</sup>

We consider one further account. In adults, sunk cost predictions could hinge on avoiding negative emotional reactions. For example, adults might reason about the flower scenario as follows: 1) The girl feels sadder about the prospect of not keeping the flower from the tall hill; 2) The girl wants to avoid sadness; 3) So she will keep the flower from the tall hill. This account relates to other claims that emotions are central to the sunk cost bias (Arkes & Blumer, 1985; Dijkstra & Hong, 2019) and on this kind of view honoring sunk costs is not necessarily irrational—on the contrary, it is emotionally healthy. But on this account, children’s judgments are surprising: Children recognized how sinking costs can lead to negative emotions. So why didn’t they predict that characters would act to minimize these emotions?

One answer is that children do not *spontaneously* consider emotions when thinking about sunk cost scenarios—they only infer emotions if explicitly asked about them. So, perhaps children didn’t expect the girl to minimize sadness because the children who predicted which flower the girl would keep were not prompted to consider how she felt. A second answer is that children (and adults) might not see sunk costs in our scenarios as producing *strong* emotions. That is, although participants might recognize the girl feels sad about losing the flowers, they might not think she feels much sadder about losing the one from the big hill, and the difference in sadness might not be enough to drive action predictions.

The present work also speaks to children’s reasoning about rational and irrational action in general. Much previous research has suggested that expectations of rationality underlie

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<sup>14</sup> This conclusion could be too strong — children might think sunk costs can be recouped in *some* circumstances. For example, suppose that after learning she cannot keep both flowers, the girl is offered a windfall of many other flowers. Perhaps children would see this as a large gain for the girl (i.e., rather than seeing it as a large gain accompanied by a small loss).

children's social judgments. Young children anticipate that others act intentionally to fulfil their desires and goals (e.g., Gergely & Csibra, 2003; Jara-Ettinger et al., 2015; for overviews see Rakoczy, 2017, 2022). However, extant research has suggested that children struggle to predict irrational action (e.g., Goldwater et al., 2020, Sehl et al., 2021). For instance, before age 7, children fail to anticipate that a character who repeatedly reaches for a lamp at one location may continue to reach for it there (i.e., out of habit) even after it has been moved (Goldwater et al., 2020). Our findings offer more evidence that children do not predict irrational action as they did not predict that others would (irrationally) honor sunk costs. While children did understand that sunk costs affect emotions, these emotions are not in themselves irrational (Baron, 1985; Zeelenberg, 1999).

One explanation for children's difficulty predicting irrationality is that they are more rational than adults (in some respects at least). On this view, biases that contribute to irrationality (e.g., over-extending a waste-not rule) are learned (e.g., Gualtieri & Denison, 2018; Lucas et al., 2014; Seiver et al., 2012; for a review, see Buchsbaum et al., 2012; Gualtieri & Finn, 2022). This possibility conflicts with long-standing views of preschool children as pre-logical (Piaget, 1954) and may also struggle to explain why children engage in seemingly irrational actions like over-imitation (Lyons et al., 2007; c.f., Buchsbaum et al., 2011; Keupp et al., 2018). As we have seen, children's neglect of the sunk cost bias may reflect incomplete mental accounting. This could be viewed as indicative of early rationality, since some aspects of mental accounting do produce irrational biases, such as the sunk cost effect itself. More likely, though, incomplete mental accounting should be viewed as mere immaturity, since the procedures needed for full-fledged mental accounting (e.g., weighing costs and benefits retrospectively) may help save time and

effort when making decisions, and might also help guide future actions by avoiding waste before it happens (e.g., Thaler, 1999).

### **Future Directions**

Given that children succeeded in recognizing how sunk costs can impact emotions, it might seem that changing testing methods might likewise reveal that children recognize how sunk costs impact actions. One potential change would be to have children imagine that they are the ones collecting the objects. However, previous work has already used this approach and found otherwise (Baron et al., 1993; Sehl et al., 2021). Another change might be to use scenarios where the choice between items is more consequential. In our tasks, children might have felt the choice didn't matter much. For example, even though the girl could only keep one flower, children probably anticipated that many other flowers would be readily available to her in the future.

Further methodological changes might also tell us more about how children see the relation between sunk costs and emotions. One potential change would be to use continuous measures that include a midpoint. This could reveal the degree to which children think the character will be sadder about losing one item rather than the other. It might also be informative to examine judgments about interpersonal sunk cost scenarios (Olivola, 2018), where costs are incurred by people besides the main character. An example would be if the girl's friends collected the flowers for her and she had to choose which to keep and which to discard. With these scenarios, the girl might not feel sadder about giving up the costlier flower, but the choice might prompt other emotions—perhaps guilt.

## **Chapter Four**

### **Children use effort, waste, and negative emotion to predict the sunk cost bias**

Young children are not biased by sunk costs—they do not expect that others’ choices will be swayed by costs incurred in pursuing an object or goal. Consider a story where a girl collects two identical flowers: one from a tall hill that was difficult to climb and the other from a short hill that was easy to climb. When asked which flower she will keep, adults mostly predict she will choose the flower from the taller hill, suggesting they expect her to be biased by sunk costs. However, 4-7-year-olds choose between them equally (Sehl et al., 2021; 2024). Other studies also find that children do not predict actions will be biased by sunk costs (Webley & Plaisier, 1998; see also Klaczynski & Cottrell, 2004; Morsanyi & Handley, 2008). For instance, when 5-12-year-olds imagined creating two drawings for an art exhibit but could only submit one, they showed no preference for the drawing they took longer to make (Baron et al., 1993).

Why do children neglect sunk costs when predicting actions? On one account, young children may consider sunk cost scenarios in a fundamentally different way than adults. Adults likely see sunk costs as causing waste or negative emotions, which can be reduced or minimized. In the flowers scenario, for instance, adults might think that giving up this flower means that all her effort to collect it is wasted (Arkes, 1996; Arkes & Blumer, 1985; Larrick et al., 1990). They might also anticipate the girl would feel sadder about giving up the flower from the taller hill because she worked so hard to get it (Arkes, 1996; Dijkstra & Hong, 2019; see also Wong & Kwong, 2007; Zeelenberg & Van Dijk, 1997). To avoid wasted effort and negative emotions, adults predict the girl will be biased by sunk costs and choose the flower from the taller hill. However, this choice is irrational—no matter which flower is kept, the effort spent on both is irrecoverable, as the investment is effectively ‘sunk’ (e.g., Thaler, 1980). So, while choosing the

high-cost flower may seem to avoid waste or make her feel less sad, the choice does not actually recoup the effort put into obtaining them.

On this account, young children might be insensitive to sunk costs because they do not see incurred costs as leading to waste or negative emotions. Children show signs of understanding that it is wasteful to throw away physical resources (see Choshen-Hillel et al., 2020; Sehl et al., 2023; Sorokowska et al., 2020). However, this understanding develops relatively late at age six, and says nothing about whether children can see *effort* as wasted. Younger children do expect that others will minimize effort in pursuing goals—around age four, children judge that an agent will complete easier tasks than harder ones for a reward (Bennett-Pierre et al., 2018), and will choose a shorter path than a longer path to reach their goal (Gönül & Paulus, 2021; see also Gergely et al., 1995; Liu & Spelke, 2017; Mascaro & Csibra, 2022; Paulus & Sodian, 2015; Lucca et al., 2020). But, these expectations may not involve considerations of waste—instead, it could reflect the understanding that people achieve goals quickly. This account might be weaker for negative emotions though, as children understand that sunk costs lead to negative emotion—around age 5, children expect others will be sadder about leaving behind objects that were difficult to obtain (Sehl et al., 2024).

In this paper, we examine an alternative explanation for why children do not predict the sunk cost bias. Like adults, children may understand that sunk costs lead to waste and negative emotions. However, unlike adults, children might not spontaneously consider waste and emotions when predicting the girl's choice. This aligns with other instances where children can make inferences, predictions, and choices, but struggle to make them spontaneously (e.g., Atance et al., 2017; Edwards et al., 2019; Engle & Walker, 2021; Legare & Lombrozo, 2014; Nyhout et al., 2019; Walker et al., 2014; Williams & Lombrozo, 2010). For example, 4-6-year-olds fail to

connect probability with surprise, predicting others will be equally surprised by improbable and impossible outcomes (Doan et al., 2018). While this initially suggested that children do not understand the connection between surprise and emotion, further studies showed that when 6-year-olds were prompted to consider probabilities of outcomes, children do understand others are more surprised by improbable than likely events.

Similarly, children may need prompting to predict the sunk cost bias. Asking children to think about effort could bring them to be biased by sunk costs. Children might anticipate the girl will keep the flower from the taller hill if they are first asked which flower was harder for the girl to obtain. Similarly, children might also predict the sunk cost bias if prompted to think about waste or negative emotions. For instance, if children are first asked which flower would be more wasteful to throw away or which flower the girl would be sadder about giving up, they might expect the girl will choose the flower from the taller hill. These waste and negative emotion prompts could more directly encourage children to predict the sunk cost bias because they highlight factors that typically lead to sunk cost reasoning.

We tested these possibilities three experiments. In each experiment, children aged 5-7-years-old saw vignettes about agents who collected items that were easy and difficult to obtain, and were asked which items the agents would keep. Before being asked this action judgment, children were asked a negative emotion, effort, waste, or control prompt.

### **General Method**

Materials, data, and analysis code are available online at:

[https://osf.io/wk78d/?view\\_only=e0667afd3664441c8049906f92fb354b](https://osf.io/wk78d/?view_only=e0667afd3664441c8049906f92fb354b). Children were mostly tested individually in-person at schools in the Waterloo region ( $N = 432$ ). Some children were also tested online in a live video call ( $N = 51$ ), in the presence of their parent or guardian who

was instructed to look down or to turn away from the screen while testing took place. The percentage of children tested in online was 9% in Experiment 1, 5% in Experiment 2, and 21% in Experiment 3.

In each experiment, children were told two stories in a fixed order (boy with rocks first, girl with flowers second), with the location of the high-cost object counterbalanced across stories (right side in first story, left side in second).

In all experiments, before analyzing children's responses to the keep question, we first analyzed children's initial responses to the prompt questions. Responses were coded as 1 if children answered correctly on their first attempt (i.e., selected the high-cost object), and 0 if they failed to respond or answered incorrectly (i.e., selected the low-cost object) on their first attempt. Results were analyzed using generalized estimating equation (GEE) models (independent correlation matrix), with prompt condition and age in months (mean-centered) entered as a covariate. These models were run using the `geepack` package for R (Højsgaard et al., 2006), and passed through the `joint_tests` function from the `emmeans` package to produce an omnibus test (Lenth et al., 2019). Bonferroni corrected pairwise comparisons were also conducted using the `emmeans` package. Single-sample tests comparing children's responses to chance were performed by running separate intercept-only GEE models for each condition.

Of primary interest was children's responses to the action prediction question. Responses were analyzed using GEE models for binomial data, with keep responses as the outcome variable, and prompt condition and age in months (mean-centered) as factors. We retained data from all children regardless of their success on the prompt question; in Appendix B, we report the percentage of trials that children passed the prompts. Exclusion children who failed the prompt does not impact the results (see Appendix C).

We initially planned to analyze initial responses to the prompts data using binomial logit GEE models. However, children's responses to the prompt questions showed little variability as children mostly chose the high-cost object. This resulted in an unusual model output where the analysis ran despite the lack of variance and age effects were not reflecting the trends in the graphs. As a result, we switched to a Poisson error structure for the prompt analyses, but still used the binomial logit structure for the action prediction analyses.

## Experiment 1

### Methods

**Participants.** We tested 180 children aged 5- to 7-years-old ( $M_{\text{age}} = 6;5$  [years;months], range = 5;0-7;11, 84 female, 94 male, 1 undisclosed; 60 children per age in years).

**Procedure.** Children saw two stories in which an agent collected two identical objects—one that was easy to retrieve ('low-cost' object) and one difficult to retrieve ('high-cost' object), see Figure 11. For example, in one story, a girl collected two flowers, one from a short hill and the other from a tall hill. In the other story, a boy collected two rocks, one from a shallow sandpit and the other from a deep one. After the agents collected their objects, their parent said that they could not keep the objects.

Children were then assigned to one of three between-subjects conditions. These differed only in the prompt question children were asked. In the Sad condition, children were asked which item the agent was sadder about. In the Effort condition, children were asked which item was harder for the agent to get. In the Control condition, were asked which item was from the bigger hill. After answering the prompt question, children were told that the agent could keep one object, and were asked which one they would keep.

If children did not respond to the prompt question or answered incorrectly, the story was repeated from the beginning and the prompt as asked again. If they failed to respond or answered incorrectly on their second try, the experimenter told them the correct answer, and then moved on to asking the keep question. We retained data from all children regardless of their success on the prompt question.

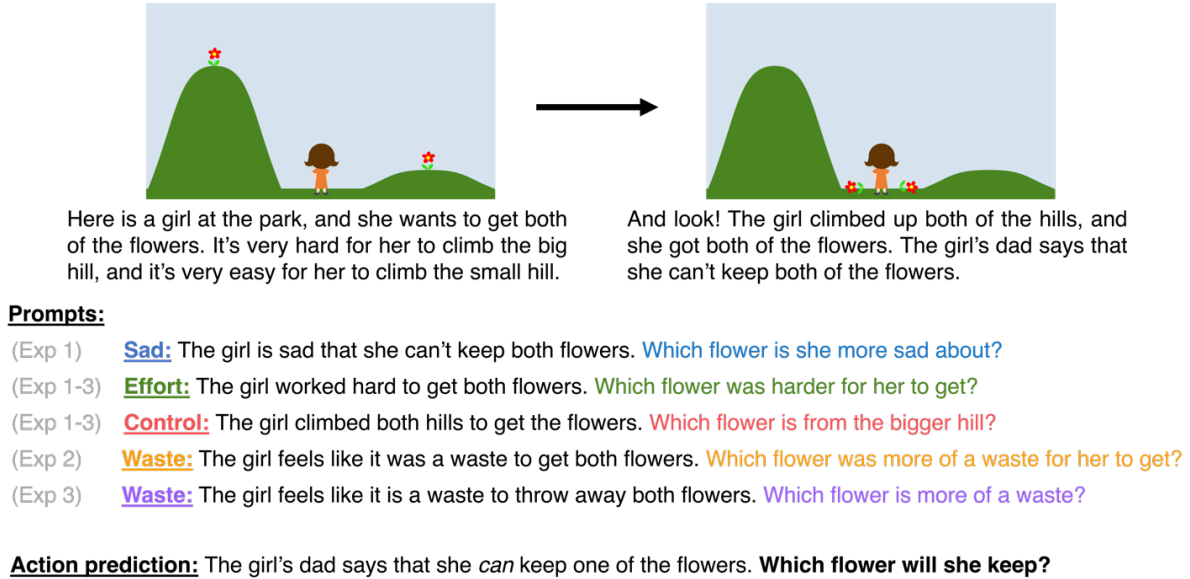


Figure 11. Sample stimuli and script for all experiments.

## Results

**Prompt questions.** We first analyzed children's *initial* responses to the prompt questions assess whether they could correctly answer them. Of particular interest was whether children could predict that agents would be sadder about high-cost objects (Experiment 1) and infer that high-cost objects were more wasteful (Experiments 2 & 3).

Figure 12 (left) shows children's initial responses to the prompt questions. A GEE with prompt condition and age revealed a main effect of condition,  $\chi^2(2) = 12.00, p < .001$ . Pairwise comparisons showed that children were more likely to select the high-cost object in effort and control prompts than the sad prompt,  $p < .001$ , but responses for the effort and control prompt

did not differ,  $p > .999$ . There was a main effect of age  $\chi^2(1) = 6.00, p = .015$ , as older children were more likely than younger ones to select the high-cost object.

There was also an interaction between condition and age,  $\chi^2(2) = 4.36, p = .014$ . This interaction resulted because older children were more likely than younger ones to select the high-cost object in the sad condition,  $p < .001$ . To pinpoint when children's responses in the sad condition differed from chance, we examined 95% confidence intervals. The confidence intervals revealed that responses in the sad condition first diverged from chance at 5;3,  $CI_{95\%} [0.51, 0.76]$ . However, responses did not vary with age in the effort or control conditions,  $ps \geq .247$ . Single-sample tests confirmed that children mostly chose the high-cost object in all prompt conditions, all  $ps < .001$ .

Together, children's responses to the prompt questions show that they understood that high-cost objects were more effortful to obtain and can predict that the high-cost object would lead to greater negative emotion.

**Action prediction.** Figure 12 (right) shows children's responses to the keep question across prompt conditions. Children's responses were analyzed using a single GEE with prompt condition and age as predictors. The analysis revealed a main effect of age,  $\chi^2(1) = 9.22, p = .002$ , as older children were more likely to select the high-cost object than younger children. There was also a main effect of condition,  $\chi^2(2) = 4.78, p = .009$ . Bonferroni-corrected pairwise comparisons showed that children were more likely to select the high-cost object in the effort condition compared to the control condition,  $p = .011$ , however the sad condition did not differ significantly from either the effort condition,  $p = .910$ , or control condition,  $p = .131$ . There was no interaction between age and condition,  $\chi^2(1) = 2.09, p = .352$ .

To pinpoint when children's responses in each condition differed from chance, we examined 95% confidence intervals. The confidence intervals revealed that responses in the effort condition first diverged from chance at 5;11,  $CI_{95\%} [0.52, 0.75]$ , but responses in the control condition never differed from chance.

**Exploratory analysis.** We also conducted an exploratory analysis to follow-up on mixed results for the keep question in the sad condition. Children's responses in the sad condition did not differ from the effort condition (i.e., where children mostly chose high-cost objects) or the control condition (i.e., where responses were at chance-level). But, the confidence interval shows that responses in the sad condition differed from chance with age. To further explore children's responses, we reran the analysis without 5-year-olds, since visual inspection of Figure 12 (right) suggested that they responded at chance-level in all three conditions, possible masking differences among older children.

The GEE revealed a main effect of condition,  $\chi^2(1) = 6.09, p = .003$ , as children were more likely to select the high-cost object in the effort and the sad conditions than the control condition,  $ps \leq .015$ . However, responses did not differ across the sad and effort conditions,  $p > .999$ . There was no effect of age,  $\chi^2(1) = 1.81, p = .180$ , nor an interaction between condition and age,  $\chi^2(1) = .090, p = .914$ . Single-sample tests showed that children selected the high-cost object 75% of the time in the sad and effort conditions, which was greater than chance-level,  $p < .001$ , however children only selected the high-cost object 48% of the time in the control condition, which did not differ from chance,  $p = .705$ .

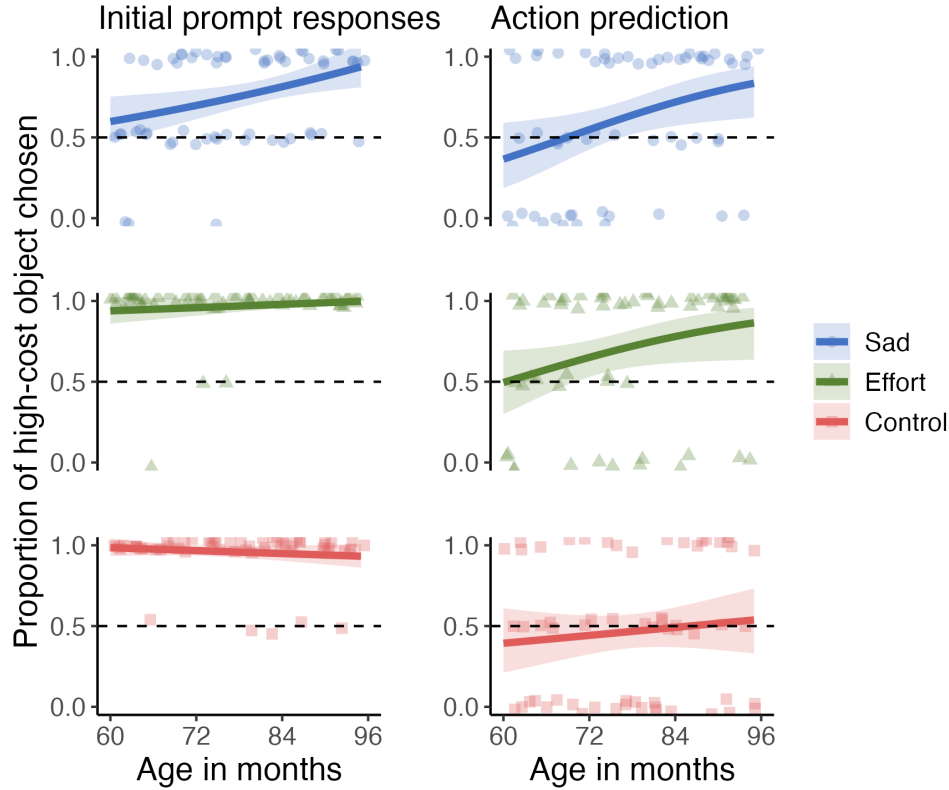


*Figure 12.* Responses in Experiment 1, with initial responses for prompt questions on the left and responses to the keep question (by condition) on the right. In all graphs, colored bands show 95% confidence intervals, and points are jittered to avoid overplotting.

## Discussion

Around age 6, children prompted with effort predicted that the agents would keep high-cost objects. Children prompted with negative emotions also showed signs of predicting the bias, but the findings were less clear cut when we looked at children’s responses across the full age range (i.e., compared to when focusing on the older children). In contrast, children who were asked the control prompt chose between the objects at chance-level. Together, these findings provide preliminary support for the spontaneity account. The effectiveness of the sadness prompts cannot be the result of low-level response strategies, since this strategy would have also led to sunk cost predictions with the control prompt. For instance, it cannot be that the prompt simply emphasized selecting the high-cost object, or prompted “more-is-more” reasoning (see

Stavy et al., 2002), where children expect agents will keep objects associated with greater sadness, effort, or larger obstacles. If children had relied on this reasoning, they would have predicted agents would keep high-cost objects even in the control condition.

In the next experiment, we further test the spontaneity account by examining whether children will predict the sunk cost bias when prompted to think about waste. Many accounts suggest that waste is central to sunk cost reasoning in adulthood (e.g., Arkes, 1996; Arkes & Blumer, 1985; Larrick et al., 1990). Furthermore, while the present experiment echoed recent work in showing that children can see sunk costs as leading to sadness (Sehl et al., 2024), it is unknown whether children recognize waste in sunk cost scenarios.

## Experiment 2

### Methods

**Participants.** We tested 184 children aged 5- to 7-years-old ( $M_{\text{age}} = 6;5$ , range = 5;0-7;11, 87 female, 96 male, 1 other; with 60 children per age in years, plus a few extras).

**Procedure.** Children saw the same stories as before, and were asked one of three prompt questions: waste, effort, or control. For the waste prompt children were asked, “Which flower was more of a waste for her to get?”. The Effort and Control prompts were identical to before, with one exception. The control prompt was slightly adjusted to match the other prompts more closely. Instead of asking “which flower *was* from the bigger hill” as in Experiment 1, children were asked “which flower *did she* get from the bigger hill”. This way, all prompts included the agent. Finally, children were asked which object the agent would keep.

### Results

**Prompt questions.** Figure 13 (left) shows children’s initial responses to the prompt questions. The condition by age GEE revealed a main effect of condition,  $\chi^2(2) = 4.26$ ,  $p = .015$ .

Pairwise comparisons revealed that children were more likely to select the high-cost object in the effort than the waste condition,  $p = .031$ , and in the control condition than the waste condition,  $p = .014$ . However, children were equally likely to select the high-cost object in the control and the effort condition,  $p \geq .999$ . There was no main effect of age,  $\chi^2(1) = 0.04$ ,  $p = .945$ , and no interaction between condition and age,  $\chi^2(2) = 2.29$ ,  $p = .103$ . Single-sample tests confirmed that children mostly chose the high-cost object in all prompt conditions, all  $ps < .001$ .

Together, children's responses to the prompt questions show that they understood that high-cost objects were more effortful and wasteful to obtain.

**Action prediction.** Figure 13 (right) shows children's responses to the keep question across prompt conditions. The age by condition GEE revealed a main effect of age,  $\chi^2(1) = 5.10$ ,  $p = .025$ , as older children were more likely to select the high-cost object than younger children. There was also a main effect of condition,  $\chi^2(2) = 4.58$ ,  $p = .010$ . Bonferroni-corrected pairwise comparisons revealed that children were more likely to select the high-cost object in the effort condition than the waste condition,  $p = .014$ , but the control condition did not differ from the effort condition,  $p > .999$ , or the waste condition,  $p = .074$ . There was also an interaction between condition and age,  $\chi^2(2) = 4.58$ ,  $p = .011$ . This interaction resulted because choices of the high-cost object increased with age in the effort condition,  $p < .001$ , but were not affected by age in the waste or control conditions,  $ps \geq .555$ . In the effort condition, children first chose the costly item at rates exceeding chance at age 6;7,  $CI_{95\%} [0.52, 0.76]$ . Also, single-sample tests against chance revealed that children in the waste condition selected the high-cost object 37% of the time, and this was significantly below chance-level,  $p = .019$ . Children in the control condition selected the high-cost object 54% of the time, and this did not differ from chance-level,  $p = .434$ .

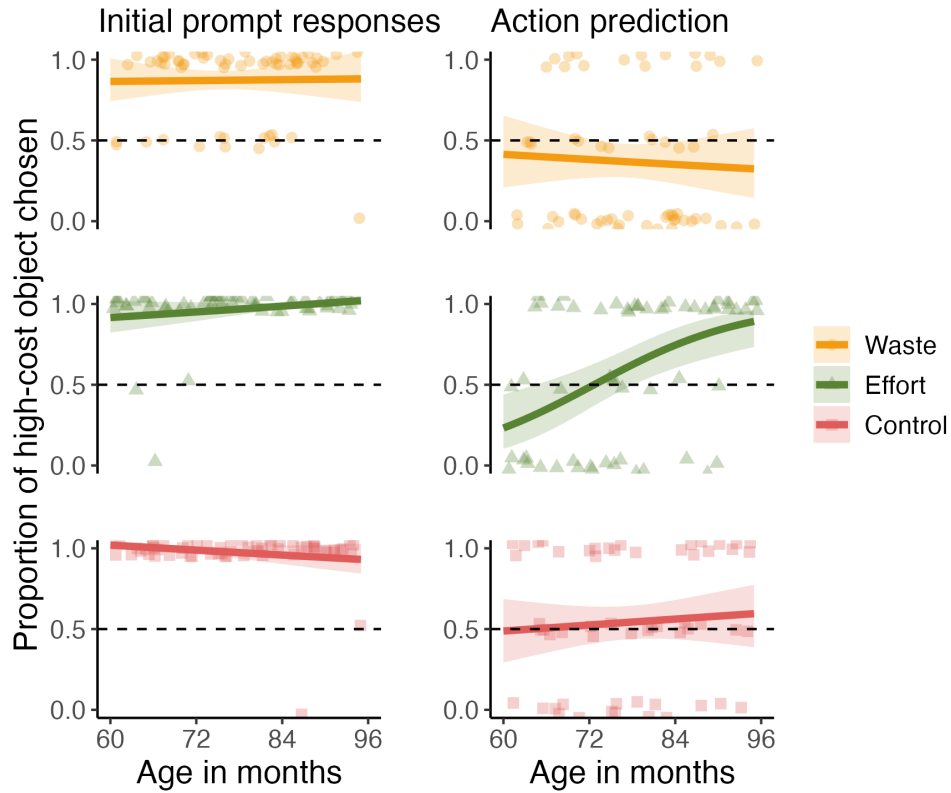


Figure 13. Responses in Experiment 2, with initial responses for prompt questions on the left and responses to the keep question (by condition) on the right.

## Discussion

Children prompted to think about effort again predicted the sunk cost bias. However, contrary to our expectations, children prompted to think about waste did not do this. These children did recognize waste in the sunk cost scenario, but made a reverse action prediction: They anticipated that the agents would keep the low-cost objects. One explanation for why children did not predict the sunk cost bias is that the prompt led children to view the high-cost object less favorably. The prompt question asked, “*Which flower was more of a waste to get?*”. *This phrasing could have led children to perceive the high-cost object as undesirable and not worth collecting in the first place, bringing children to instead predict the agent would keep the low-cost object.*

To address this, we asked children in the next experiment a different waste question: “Which flower would be more of a waste *to throw away*?”. This question still prompts children to consider waste, but focuses on the wastefulness of losing the objects rather than the wastefulness of obtaining them. This next experiment again also looked at the effects of prompting children to think about effort. We did not include 5-year-olds, as prompting had little or no effect on their action predictions in the previous experiments—a finding we revisit in the General Discussion.

### Experiment 3

#### Methods

**Participants.** We tested 120 children aged 6- to 7-years-old ( $M_{\text{age}} = 6;11$ , range = 6;0-7;11, 62 female, 58 male; 60 children per age in years).

**Procedure.** Children saw the same stories as before, and were asked one of three prompt questions: waste, effort, or control. For the waste prompt children were asked, “The girl feels like it’s a waste to throw away both flowers. Which flower is more of a waste?”. The Control prompt was identical to Experiment 1. The Effort prompt was similar to previous experiments, but was slightly adjusted to match the wording of the other prompts: “Which flower *was* harder to get?”. That way, none of the prompts included the agent as the subject of the sentence. After the prompt question, children were asked which object the agent would keep.

#### Results

**Prompt questions.** Figure 14 (left) shows children’s initial responses to the prompt questions. We could not run the full GEE because there was no variance in the effort condition—all children selected the high-cost object on both trials. We proceeded to analyze the data in a condition by age GEE without the effort condition. The analysis revealed a main effect of

condition,  $\chi^2(2) = 20.51, p < .001$ , as children were more likely to select the high-cost object in the control than the waste condition. There was no main effect of age,  $\chi^2(1) = 2.99, p = .086$ , and no interaction between condition and age,  $\chi^2(2) = 3.85, p = .060$ . Single-sample tests confirmed that children mostly chose the high-cost object in all prompt conditions, all  $ps < .001$ . Together, children's responses to the prompt questions show that they understood that high-cost objects were more effortful to obtain and would be more wasteful to throw away.

**Action prediction.** Figure 14 (right) shows children's responses to the keep question across prompt conditions. The age by condition GEE revealed a main effect of age,  $\chi^2(1) = 6.64, p = .011$ , as older children were more likely to select the high-cost object than younger children. There was also a main effect of condition,  $\chi^2(2) = 8.62, p < .001$ . Bonferroni-corrected pairwise comparisons revealed that children were more likely to select the high-cost object in the effort condition than the control condition,  $p < .001$ , and in the waste condition than the control,  $p = .048$ . However, children's responses in the waste and effort conditions did not differ,  $p = .395$ . There was no interaction between condition and age,  $\chi^2(2) = 1.50, p = .226$ .

The 95% confidence intervals show that children mostly selected the high-cost object in the waste condition by age 6;9,  $CI_{95\%} [0.51, 0.79]$ , and across all ages in the effort condition  $CI_{95\%} [0.73, 0.91]$ . Responses in the control condition never differed from chance,  $CI_{95\%} [0.36, 0.61]$ . Results from single-sample tests yield a similar interpretation. Children in the waste condition selected the high-cost object 68% of the time, and this was above chance,  $p = .017$ . Similarly, children in the effort condition selected the high-cost object 84% of the time, which was above chance,  $p < .001$ . Children in the control condition selected the high-cost object 49% of the time, and this did not differ from chance,  $p = .847$ .

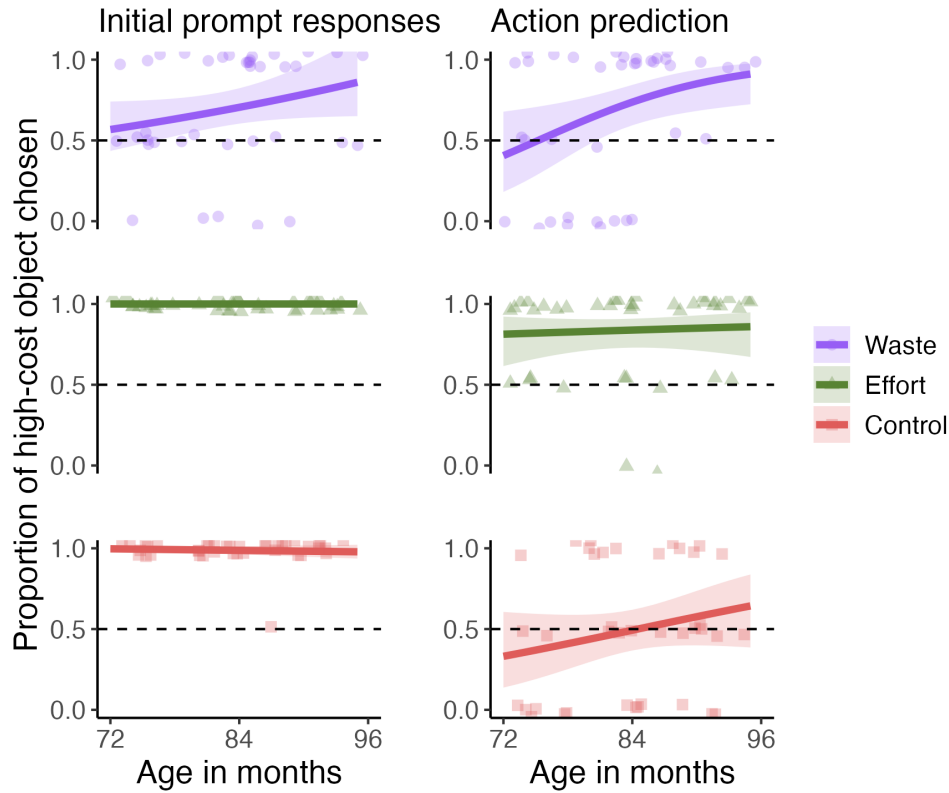


Figure 14. Responses in Experiment 3, with initial responses for prompt questions on the left and responses to the keep question (by condition) on the right.

## Discussion

We found that children prompted with effort predicted the sunk cost bias, and importantly, children prompted with waste also predicted it. This suggests that their failure to predict the bias in Experiment 2 was due to the negative framing of waste.

## General Discussion

Across experiments, children were asked to predict whether agents would keep high-cost or low-cost objects. Before making these predictions, they were asked a prompt about negative emotion, effort, waste, or a control question. Overall, answering the prompts influenced children’s subsequent action predictions. In Experiment 1, children predicted the sunk cost bias when prompted with effort—children identified that high-cost objects were more effortful to

obtain, and in turn anticipated agents would keep them. There was also some evidence that prompting children with negative emotion led them to predict the bias. Experiments 2 and 3 replicated findings for the effort prompt and also tested waste prompts. In Experiment 2, children judged high-cost objects as more wasteful to obtain, yet this led them to predict that agents would keep low-cost objects. However, in Experiment 3, children judged high-cost objects as more wasteful to throw away, and in turn expected agents would keep them. Together, the results show that by age 6, children predicted the bias when prompted with effort, around age 6 and a half for negative emotion, and by age 7 with waste.

Our findings, at least for older children, are consistent with the spontaneity account. On this account, children see sunk costs as involving greater effort, waste, and negative emotions. However, children fail to call these factors to mind on their own, and so do not spontaneously consider these factors when predicting choice. This account predicted that prompting children to think about these factors would enable them to anticipate the sunk cost bias. Overall, our findings with older children confirmed this prediction. Different versions of this account are possible though. One possibility is that children do not think about waste, effort, or negative emotion at all when reasoning about the scenario, so they require prompting to bring these factors to mind before making a prediction. This would suggest that children reason very little about the outcomes of sunk costs but can do so when prompted. Another possibility is that children do think about the agents' effort, waste, and negative emotion entirely on their own, but simply overlook these elements when predicting action. In this case, prompting does not introduce new information but instead helps children apply what they already know to their predictions. This would suggest that children may reason about the scenario to a greater extent but need prompting to see these features as relevant for action predictions.

The spontaneity account does not entirely explain the findings, though—while many children correctly answered the prompt questions, they did not *always* predict the sunk cost bias. For instance, prompts had little or no effect on 5-year-olds. This suggests a gap between prompting and action predictions. This gap is also observed when analyzing responses only from children who answered the prompt questions correctly on their first attempt (see Appendix B). The findings for children who did not respond to the prompts, then, are more consistent with an alternative to the spontaneity account, holding that children see sunk cost situations in a markedly different way than adults. One possibility is that children might not see sunk costs as leading to waste and negative emotions, and this prevents them from recognizing why costs could sway others’ choices. But our findings suggest otherwise, since children correctly responded to the waste and negative emotion prompts. Even the youngest children in our sample predicted it was more wasteful to obtain the high-cost object and it would be more wasteful to throw the high-cost object away. By age 5 and a half, children correctly predicted agents would be sadder about leaving behind high-cost objects (see also Sehl et al., 2024).

Why, then, do children not spontaneously consider factors like effort, waste, and negative emotions when predicting agents’ choices? We suggest the reason relates to a shift in the factors that children expect agents to consider when choosing between objects. Children may think that choices between objects, like the girl’s choice between flowers, depend on factors that typically make some objects more valuable than others. These include the physical features of objects, such as their size, color, shape, weight, or quality (e.g., Suchman & Trabasso, 1966), or their uniqueness or scarcity (Echelbarger & Gelman, 2017; Ferera et al., 2020; Sehl et al., 2022). Children also expect that choices are shaped by intangible and non-obvious features of objects— from age 4, children recognize that objects previously owned by celebrities are more special than

identical objects without this history (e.g., Hartley et al., 2025; Hood & Bloom, 2008; Gelman et al., 2015; Pesowski & Friedman, 2019; see also Frazier & Gelman, 2009), and expect that others prefer handmade objects over ones created in a factory (DeJesus et al., 2022; for a review, see Pesowski et al., 2022). However, in the present scenarios, the objects did not differ in any of these ways—they looked identical and neither had a unique history, such as being owned by a celebrity. So, children might choose between them at chance because the objects were similar on all the dimensions that children usually see as impacting choices. Prompting children may remind them that other considerations, such as personal effort and avoiding waste and sadness, could also be relevant. It is an open question though, for why prompting only leads some children to predict the sunk cost bias. One answer is that older children may see keeping high-cost objects as making up for sunk costs, whereas younger children do not.

### **Future Directions**

Our findings raise several questions that could be addressed in future work. One future direction is to determine why some prompts were more effective than others. Effort was the most effective in leading children to predict the sunk cost bias. Children were especially adept at this effort prompt—at all ages, they recognized that the flower from the taller hill was harder to get. This prompt was also the most successful at leading children to predict the bias, as it was the earliest to lead children to predict the agent would keep the high-cost object. To follow-up on this, future work could first confirm the robustness of the difference. A study could systematically compare the relative effectiveness of prompts, examining when children first succeed on different prompts and when prompts lead to sunk cost predictions. Such comparisons could suggest that effort the most intuitive factor when predicting object choice—though the objects are identical, highlighting that one was more effortful to obtain could remind children of

the simple idea that objects that are difficult to acquire are worth keeping (Benozio & Diesendruck, 2015; Marsh et al., 2018; see also Inzlicht et al., 2018; Kiefer et al., 2013). Another explanation is that the effort prompt led children to think about waste, which might have been more readily understandable for children than asking them about waste directly.

Another future direction is to better understand how the prompts affected children's responses. One puzzling finding is that children had differing action predictions across the waste prompts. When children were prompted to see the high-cost object as more wasteful to obtain (Experiment 2), they predicted the agent would keep the low-cost object. But when prompted to see the high-cost object as more wasteful to throw away (Experiment 3), children predicted the agent would keep it. This discrepancy raises the concern that the prompts did not work as intended. Rather than bringing children to consider how factors like waste affect actions, the prompts might have steered children's predictions based on *valence*. Identifying the high-cost object as more of a waste to obtain could have led children to view keeping it as negative and should be avoided. By contrast, identifying the high-cost object as more wasteful to throw away could have led children to see losing it as negative and should be avoided.

However, this account cannot explain the effect of the sadness prompt. On the valence account, this prompt should lead children to see keeping high-cost objects as negative. Identifying the identifying the high-cost flower as involving greater sadness would lead children to see keeping it as negative. But contrary to this prediction, children anticipated the agent would keep the high-cost object.<sup>15</sup> This suggests that prompting really does lead children to reason like adults, allowing them to predict the bias by reasoning about effort, waste, and negative

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<sup>15</sup> The effort prompt might also speak against this account. Identifying the high-cost object as involving greater effort may lead children to see throwing it away as positive, as it was unnecessarily burdensome to obtain. It is also possible, though, that effort is neither positively or negatively valenced, since effort is both *valued* and *costly* (Inzlicht et al., 2018; Kiefer et al., 2013). Regardless, this presents a challenge for the valancing account, as it fails to explain why children predicted the agent would keep the high-cost object, instead of being at chance.

emotion—factors they do not spontaneously take into account. Together, these future directions could reveal the mechanism behind prompting and the origins of sunk cost reasoning.

## **Conclusion**

Overall, our findings clarify why children do not predict the sunk cost bias. While it may have seemed like children were entirely unable to see sunk costs as biasing actions, the findings suggest that children can understand the consequences of sunk costs. Children recognized how sunk costs relate to waste, negative emotion, and effort, and when prompted, could anticipate others would be biased by sunk costs. However, their reasoning remains limited, as they do not spontaneously see these factors leading to biased choices. Together, the findings suggest that sunk cost predictions develop gradually: Children first grasp how sunk costs lead to consequences like waste and negative emotion, and only later integrate these factors into their predictions of others' actions.

## **Chapter Five: General Discussion**

### **Major findings**

Across ten experiments, I examined how children reason about sunk costs when predicting choices. In Chapter Two, I found that children do not anticipate that sunk costs bias others' choices. When predicting which of two objects an agent would keep, 5- to 6-year-olds chose between high- and low-cost objects equally. However, adults expected that agents would keep high-cost objects, suggesting they anticipate others will be biased by sunk costs. Across four experiments, children did not make sunk cost predictions when predicting others' choices, their own hypothetical choice, or interpersonal choices where children imagined choosing between others' objects. However, children were sensitive to the effort required to collect the objects—when predicting which objects agents would retrieve in the future, children selected the low-cost ones. This suggests that children's inability to predict the sunk cost bias is not due to a lack of understanding of the effort involved with collecting the objects. Together, the findings provide clear evidence that children do not anticipate the sunk cost bias in a variety of scenarios.

In Chapter Three, I tested between two competing accounts for why children overlook sunk costs when predicting actions. On one account, children do not see sunk costs as having any causal relevance for future outcomes, such as negative emotions. On the other account, children can see sunk costs as having causal relevance, but do not think future actions can make up for sunk costs. These accounts differ in their predictions for whether children see sunk costs as leading to negative emotion. In three experiments, 5- to 7-year-olds predicted agents' actions and emotions. Consistent with previous findings, children did not anticipate that sunk costs would impact actions—they chose between high- and low-cost objects at chance when predicting which would be kept or fixed. However, children predicted that agents would feel sadder about high-cost objects. These findings challenge the account that children see sunk costs as having a

limited causal role. Instead, the findings support the alternative account that children can see sunk costs as causally related to future states, but do not predict actions are biased because they do not see those actions as making up for sunk costs.

In Chapter Four, I investigated whether children predict the sunk cost bias when prompted to think about effort, waste, or negative emotion. Across three experiments, I found that prompting led children to predict agents would keep high-cost objects. Children predicted the bias by age 6 when asked which object was more difficult to obtain, and by age 7 when asked which would be more wasteful to throw away. However, prompting children to consider waste did not always lead to sunk cost predictions—after asking which object was more wasteful to obtain, children instead predicted agents would keep low-cost objects. Children also showed signs of predicting the bias when prompted to consider which object would make the agent feel sadder about leaving behind. Together, these findings suggest that children’s reasoning about sunk costs is not fundamentally different from that of adults. Children recognize that sunk costs involve waste, negative emotion, and effort and see this as leading to biased actions. However, children do not anticipate the bias because they do not spontaneously consider these factors when predicting choices.

Overall, these findings reveal that children are not entirely unable to reason about sunk costs. Although children do not spontaneously predict the sunk cost bias, they can see sunk costs as relating to wastefulness and negative emotion, and when prompted, they anticipate others’ biased actions. The findings suggest the bias develops gradually, as young children see sunk costs leading to consequences like waste and negative emotion, but only later see integrate these factors into their predictions of others’ actions. In the remainder of this dissertation, I discuss the implications of these findings for the development of cost-based reasoning and theories of the

sunk cost bias. I also explore how children's sunk cost predictions contribute to our understanding of their theory of mind, and suggest directions for future work.

### **Children's reasoning about costs**

This work advances our understanding of the development of cost-based reasoning. Prior work established that costs influence actions and thinking from an early age. For instance, infants around 18 months selectively expend effort towards their goals: They choose shorter rather than longer paths to crawl to their mother (Paulus et al., 2015), and are more likely to help others when it requires less effort (Sommerville et al., 2018; see also Radovanovic et al., 2024). Infants also strategically incur costs when pursuing goals. For instance, 18-month-olds showed greater persistence and effort in achieving a goal when they observed someone else succeed compared to when another person's efforts revealed that the goal was impossible (Lucca et al., 2020). Beyond infancy, costs continue to shape children's own actions and preferences. For example, 5-year-olds prefer objects they made over ones that were made by others (Marsh et al., 2018) and 6-year-olds distribute fewer objects when they were obtained effortfully (Benozio & Diesendruck, 2015; but see Kiefer et al., 2023).

Children also use costs to make inferences about *others*, when predicting actions, judging choices, inferring preferences, and making sociomoral evaluations (e.g., Gergely & Csibra, 2003; Chu & Schulz, 2023; Zhao & Kushnir, 2023). From infancy, they expect agents to minimize costs when pursuing goals (e.g., Bennett-Pierre et al., 2018; Gergely & Csibra, 2003; Gönül & Paulus, 2021; Liu & Spelke, 2017). Children also use costs to infer preferences and competence, recognizing that others might act against their preference if it is too costly or beyond their capability (Jara-Ettinger et al., 2015; 2016). Costs shape children's sociomoral judgments as well—they view costly helping as especially praiseworthy (Zhao & Kushnir, 2023; McCrink et

al., 2010) and consider both costs and need when evaluating helping decisions (Radovanovic et al., 2023; Sierksma et al., 2014; see also Bennett-Pierre et al., 2018).

My research builds on this earlier work by exploring how children recognize that past costs can influence people's valuations and future actions. The findings show that children do not spontaneously make this connection, as they expect agents to select between high- and low-cost objects equally when choosing which one to keep. However, with prompting, children anticipate that past costs would influence which objects other agents will choose to keep. Overall, the findings suggest an asymmetry in how children consider costs—young children readily see others' valuation of objects as determining the costs they will incur to obtain them, but they do not yet see costs others have incurred as affecting how much they value them.

### **Developmental trajectory of sunk cost predictions**

Before my studies, relatively little was known about the development of the sunk cost bias. Some research suggested that the bias gradually diminishes with age. For instance, some studies found that 8-year-olds were more biased by sunk costs than 11-14-year-olds (Klaczynski & Cottrell, 2004); 11-14-year-olds were more biased by sunk costs than older adolescents age 15+ (Klaczynski, 2001); and younger adults around ages 18-25 were more biased by sunk costs than older adults aged 60+ (Bruin de Bruin et al., 2007; 2012; 2014; Del Missier et al., 2013; Eberhardt et al., 2019; Huai et al., 2023; Strough et al., 2008; 2011b). Some interpreted this decline as reflecting improvements in reasoning or greater experience with age (e.g., Strough et al., 2011a). For instance, Klaczynski & Cottrell (2004) posited that both children and adults see sunk cost scenarios as involving waste, but adults are less biased than children due to their developed metacognitive abilities. However, these conclusions are tenuous as other work

observed no differences in the bias across young and older adulthood (Del Missier et al., 2020; Parker et al., 2018).

These conclusions are also tenuous because there is hardly any research exploring children's predictions in sunk cost scenarios. Only three studies examined children younger than age 7 (Baron et al., 1993; Morsanyi & Handley, 2008; Webley & Plaisier, 1988), with most finding that young children were not biased by sunk costs. These findings provide evidence against the idea that the sunk cost bias decreases with age: Older children are more biased by sunk costs than younger ones (Morsanyi & Handley, 2008), or may be equally unbiased by sunk costs as younger children (Baron et al., 1993; Webley & Plaisier, 1998).<sup>16</sup> These findings might instead provide evidence for the opposite pattern, that the sunk cost bias *increases* with age. Overall, there was little consensus regarding the developmental trajectory.

My studies are the first significant exploration of how young children reason about sunk costs. I consistently found that children do not spontaneously predict the sunk cost bias, challenging claims that the bias is prevalent in childhood and decreases with age (e.g., Klaczynski & Cottrell, 2004; Strough et al., 2011a). Instead, my findings align with the view that the bias increases with age (Arkes & Ayton, 1999). Both of these perspectives hinge on whether children reason about waste—some argue that children *are* biased by sunk costs because they reason about waste (Klaczynski & Cottrell, 2004), but others suggest they *are not* biased by sunk costs because they lack experience with waste or the ability to reason about it (Arkes & Ayton, 1999). None of this earlier work directly tested this though. My work was the first to show that children *can* recognize sunk costs as wasted, and when children are reminded about waste, they

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<sup>16</sup> These developmental studies should be interpreted with caution as they involve various confounds that may have led children to ignore sunk costs. For instance, children may have preferred low-cost options because they involved less future effort than high-cost options (Klaczynski & Cottrell, 2004), or they aligned with their imagined preference (Baron et al., 1993). Some of these scenarios might not truly involve sunk costs at all (Webley & Plaisier, 1988).

can predict others' will make biased choices. I provide a more detailed discussion of these findings in the following sections.

After I completed my research, a new study was published that also found young children do not predict the sunk cost bias (Hamzagic et al., 2025). In this study, participants aged 2-97 saw pairs of vignettes in which a character either effortfully created an object or was given the object by someone else (e.g., bought ingredients and baked a pizza vs. given leftover pizza from a neighbor). The character disliked the pizza, and participants predicted how much the character would eat. It was only by age 13 that participants predicted the character would eat more when the pizza was effortfully made compared to when it was given for free. These recent results broadly support my findings showing that young children do not predict the sunk cost bias. Moreover, they suggest that even if I had expanded my age range, I would not have found evidence of sunk cost predictions until early adolescence.

Furthermore, this recent work by Hamzagic et al. (2025) may speak to children's predictions in another type of sunk cost scenario. My studies primarily focused on adoption scenarios, where children predicted which of two collected objects an agent would keep. In progress scenarios, the agent is investing in a project but has not yet completed it, and the prediction concerns whether the agent will persist (for a discussion of this distinction, see Moon, 2001; Roth et al., 2015). The key difference is that in adoption scenarios, the goal has already been achieved, while in progress scenarios, it has not, and the agent must decide whether to continue investing resources. Importantly, a bias by sunk costs in these different choice structures may reflect different reasoning. For instance, people may make biased choices in progress scenarios due to an escalation of commitment (Schaubroeck & Davis, 1994) or a desire for completion (e.g., Conlon & Garland, 1993), but these considerations cannot explain their

biased choices in adoption scenarios. The Hamzagic et al. (2025) study involves persistence as children predicted how much a character will continue pursuing a goal even though it is subpar (i.e., eating a pizza when it tastes bad). Their findings, when considered alongside mine, suggest that children's sunk cost predictions might not differ substantially across adoption and progress decisions as children did not predict the sunk cost bias in either.

However, there is room to further explore children's judgments in progress scenarios. The scenarios used by Hamzagic et al. (2025) had elements of adoption scenarios. Like in adoption scenarios, the character had already obtained the object, and the choice was to what extent it would be used. In a true progress scenario, the agent must decide whether to continue to invest in a goal that has not yet been completed. The Hamzagic et al. (2025) scenarios do not involve continued investment in obtaining the object, but rather the choice of how much the object will be used. Additionally, the Hamzagic et al. (2025) study involved other considerations that could have influenced participants' predictions. For example, participants might have reasoned about the character's personal involvement in creating the pizza (i.e., the IKEA effect; Marsh et al., 2018) or that the character might be unwilling to eat a neighbor's leftover pizza.

One of my experiments examined judgments about a similar choice. In this vignette, an agent collected two broken objects and participants predicted which one the agent would fix (Chapter 3, Experiment 2). This prediction might better align with progress decisions than Hamzagic et al. (2025) because fixing toys involves further investment of effort after the agent already expended effort to obtain them. But to my surprise, children and adults showed a reverse sunk cost effect—from age 6, people predicted that the agent would fix the low-cost object. One explanation for this finding is that the sunk costs to acquire the objects may have seemed negligible compared to the future cost of repairing them. Future work should test children's

predictions in scenarios that clearly involve progress decisions, such as child-friendly versions of the airplane scenario (Arkes & Blumer, 1985) or the hotel movie scenario (Frisch, 1993).

Children might recognize how persistence in failing projects leads to frustration and waste, predicting that the agent will be biased by sunk costs and continue pursuing their goal.

Alternatively, children might not predict the bias if it is challenging for them to weigh sunk costs and the failure of the goal against the agent's desire to persist.

Future research could also investigate children's predictions about different kinds of sunk costs. My experiments focused on effort, but children may reason about other sunk costs like time, money, or traded resources. For instance, in a trading study, children could be shown an agent who traded two candies for one toy and ten candies for another identical toy. Trading scenarios may be easier for children because the sunk cost is tangible and quantifiable.

Furthermore, children from age 5 see preferences as influencing trading decisions (Echelbarger et al., 2020), and commonly swap resources with others (Webley & Lea, 1993). A similar study could be conducted looking at judgments about resources bought with money. As with trades, money can be easily tracked as losses in mental accounts, whereas effort is more abstract (see Soman, 2001). This said, young children have difficulty reasoning about money (e.g., Berti & Bombi, 1981; Burris, 1983; Webley, 2005).

### **Accounts for sunk cost predictions**

In this section, I revisit three major accounts for why people show the sunk cost bias and discuss the contributions of my work. These three accounts were primarily devised to explain adults' choices, however, they do not make specific predictions about children. One exception is the waste account, as prior work has discussed the developmental trajectory of the sunk cost bias

as hinging on reasoning about waste (e.g., Arkes & Ayton, 1999; Klaczynski & Cottrell, 2004; Strough et al., 2011a).

### ***Waste***

One longstanding proposal is that people predict the sunk cost bias because they overgeneralize rules about waste (e.g., Arkes, 1996; Arkes & Hutzler, 1997; Larrick et al., 1990). On this account, people follow simple principles to minimize waste in everyday choices, but they misapply these principles to sunk cost choices, believing that honoring sunk costs prevents waste. For example, when predicting whether the girl will keep the high-cost or low-cost flower, people predict she will keep the high-cost one because they misapply the principle of underuse (i.e., *make full use of purchases*), seeing it as wasteful to leave behind the flower that was more effortful to obtain. Despite proposals that reasoning about waste underlies the sunk cost bias, few studies had tested this connection. One study found that material waste increased people's commitment to sunk costs—adults' sunk cost predictions increased when abandoning projects led to scrap waste rather than reusable materials (Arkes, 1996). Also, when rating justifications for biased actions, people find waste-based justifications more reasonable than justifications involving a desire to be consistent, learning a lesson, or punishment (Bornstein & Chapman, 1999), though, people overall judge it is more reasonable to not make biased choices in the first place.

My findings reveal two key patterns that offer insight into the waste account. First, children's responses to the waste prompts suggest they recognize sunk costs as wasted—children identified the high-cost flower as more wasteful to obtain and as more wasteful to throw away. This finding is particularly notable because there was little prior evidence that young children reason about waste. For instance, only by age 5.5 do children recommend that others minimize

wasting material resources when completing goals (Sehl et al., under review; Sehl et al., 2023), and by age 6 do they disfavor individuals who waste food by giving them fewer rewards (Sorokowska et al., 2020). However, this work does not establish that children care about waste other than throwing away material resources.<sup>17</sup> My work suggests that children recognize expended effort can be wasted.

Second, I found that children anticipated the sunk cost bias when prompted with waste—after identifying the high-cost object would be more wasteful to throw away, children predicted agents would keep it. That said, children’s predictions depended on how waste was framed, as they did not predict the bias after identifying the high-cost object was more wasteful to obtain. This could indicate that explicitly prompting children to consider waste is insufficient for them to predict the bias. Nonetheless, this discrepancy could speak to how waste contributes to sunk cost predictions. Early theoretical work specified two ways people might see waste in sunk cost scenarios: Waste as *overspending* and waste as *underuse* (Arkes, 1996). With overspending, people may find it wasteful that extra costs were incurred for the high-cost object, whereas with underuse, people find it wasteful to not fully utilize the high-cost object. My results show that children predict the bias when prompted to consider waste in terms of underuse (i.e., “Which flower would be more of a waste to throw away?”), but do not predict the bias when told to consider waste in terms of overspending (i.e., “Which flower was more of a waste to get?”). This could suggest that thinking about waste as underuse is more likely to lead to sunk cost predictions than thinking about waste as overspending, at least in childhood. Overall, my

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<sup>17</sup> While it is true that infants expect agents will take shorter paths (e.g., Gergely et al., 1995; for a review, see Gergely & Csibra, 2003), this expectation might not reflect an understanding of avoiding wasted effort, but rather reflect the assumption that people will achieve their goals quickly.

findings suggest that it is at least possible for concerns about waste to produce sunk cost predictions in children.

### *Negative emotion*

People might also predict the sunk cost bias if they expect others will avoid negative emotion. On this view, people predict agents will keep high-cost objects to avoid the distress of having worked hard for them without keeping them. Some work with adults explored how sadness and regret contribute to sunk cost reasoning (e.g., Kwak & Park, 2012; Zeelenberg & Van Dijk, 1997). For example, people who have difficulty letting go of past events are more likely to predict the sunk cost bias (van Putten et al., 2010). None of this work directly tested how negative emotions lead to sunk cost predictions or identified which negative emotions contribute to them.

I found that children see sunk costs as leading to negative emotion, as they judged agents would feel sadder about broken toys that were harder to obtain over ones that were easier to obtain. Prior work suggests that preschoolers realize negative events lead others to feel sad (e.g., Denham et al., 1994; Fabes et al., 1988; Levine, 1995; Yuill, 1984), and my findings show that sunk costs are also integrated into their theory of emotions (e.g., Doan et al., 2024; Harris, 2008; Walle & Lopez, 2020). My findings also suggest that reasoning about negative emotion contributes to sunk cost predictions. After identifying that agents would feel sadder about high-cost objects, children anticipated agents would keep them. However, the findings were mixed: Children's selection of the high-cost object in the negative emotion condition did not differ from the effort condition (i.e., when they chose high-cost objects above chance) or the control condition (i.e., when they chose between objects at chance).<sup>18</sup> So, the findings do not clearly

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<sup>18</sup> This pattern only emerges when including 5-year-olds' data. The exploratory analyses without 5-year-olds' data indicated that older children selected high-cost objects more in the negative emotion condition than the control condition.

suggest that prompting children with negative emotions leads them to predict agents will keep high-cost objects. Another reason to doubt the emotion account is that reasoning about negative emotion likely arises from reasoning about waste. People might anticipate agents feel sadder to lose high-cost objects because leaving them behind is a waste of their effort. So, reasoning about waste alone can explain the bias, without needing to invoke emotion as a separate explanation for sunk cost predictions.

One possibility is that sunk cost predictions can be supported by inferences about other negative emotions, such as anger, upset, and frustration. An alternative view is that sunk cost predictions are most specifically linked to feelings of regret. Some work with adults has emphasized the role of regret in sunk cost predictions (Zeelenberg & van Dijk, 1997; see also Arkes & Blumer, 1985; Zeelenberg & Pieters, 2007), proposing that people choose options that minimize anticipated future regret. For instance, they may predict an agent will keep a high-cost object because this choice is less likely to involve regret—they may regret keeping the low-cost object because they might feel like the effort into collecting the high-cost object was for nothing. Regret may be difficult for younger children to predict because it requires counterfactual reasoning to compare realized outcomes to alternative outcomes of what could have been. Children only understand regret by ages 6 or 7 (Weisberg & Beck, 2010; see also O'Connor et al., 2012), and so older children might infer agents feel regretful about greater sunk costs or wished that they had not collected high-cost objects. So perhaps the shift between prompted and spontaneous sunk cost predictions is linked to the development of children's understanding of regret.

## *Effort*

Some accounts posit that people predict the sunk cost bias because they see effort as imbuing value. On one account, people use effort as a heuristic for value when an object's worth is ambiguous—for instance, people rate artwork as higher in quality and more valuable when told it took longer to create than when it was made quickly (Kruger et al., 2004). In sunk cost scenarios, people might reflexively see effort as a proxy for value (Sweis et al., 2018), viewing the high-cost object as worth more even though both objects are identical. Another account is effort justification, based on cognitive dissonance theory (e.g., Aronson & Mills, 1959; Festinger, 1957; see also Norton et al., 2012).<sup>19</sup> On this view, people overvalue objects they invested effort into because it reinforces the notion that their efforts were worthwhile (Brockner, 1992; Staw, 1976; 1981; see also Cunha & Caldieraro, 2009). For example, people who underwent an effortful initiation to join a dull discussion group later rated the group as more enjoyable, presumably to resolve the psychological discomfort of having invested significant effort for a low-value reward (Aronson & Mills, 1959; see also Norton et al., 2012). In sunk cost vignettes such as the flowers scenario, adults recognize that the girl worked harder for a flower that is no better than the alternative, and so they might predict that she will overvalue it to justify her effort.

Some developmental findings using first-person tasks suggest that children treat effort in this way, either as a sign of value or as justification for valuing objects. In one study, 4-6-year-olds completed easy and difficult tasks to obtain stickers, and later could distribute them to an unfamiliar recipient. By age six, children distributed fewer stickers that were effortful to obtain,

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<sup>19</sup>Arkes & Blumer (1985) argue that it “adds little to our understanding of the sunk cost effect” (p. 137). They articulate that cognitive dissonance leads people to develop positive attitudes towards the object and the act of investing in it, however, sunk costs do not typically engender positive attitudes. For instance, the president of the airline company does not continue investing in the radar-blank plane because they like it more or begin to enjoy investing, but rather they persist to avoid waste and distress.

even when the stickers were unattractive (Benozio & Diesendruck, 2015). In line with this, children by age 5 prefer objects they created over identical ones they did not create (Marsh et al., 2019; see also Norton et al., 2012). However, rather than reflecting that children treat effort as a sign of value or justification for valuing objects, children's responses might be driven by feelings of ownership or attachment to their objects. Furthermore, other studies found that children are no more likely to overvalue their objects when they were effortful to obtain than when they were effortless to obtain (Kiefer et al., 2023; Marsh et al., 2018; Exp 2). So, effort might not lead children to overvalue objects in first-person tasks.

My findings provide mixed evidence for these effort accounts. Children did not spontaneously see effort as affecting which object the agent preferred or wanted to keep. This suggests that children might not see effort as a sign of value or justifying value in third-person tasks. At the same time, children by age 5.5 predicted the sunk cost bias when prompted with effort, suggesting that reasoning about effort might underlie sunk cost predictions. Regardless, a key prediction of effort-based accounts is that children see the objects as more appealing or desirable when greater effort was expended in obtaining them. In my experiments, children did not judge how much agents like or prefer objects, but rather how they choose between them. Future work could directly test whether people see effort as increasing value by comparing action predictions with valuation judgments. For instance, after the girl collects both flowers, participants could be asked value judgments: Which flower she likes more, finds nicer, and would sell for more money. The effort-based accounts predict that people will choose high-cost objects for both the action and valuation predictions.

Also, the effects of the effort prompt in my experiments might not speak to effort-based accounts at all. Instead, effort may have prompted children to reason about waste (or negative

emotion). For instance, asking about effort may have prompted children to reason about waste. That is, children might think about waste even when it is not directly referenced. This might initially seem unlikely because directly prompting children with waste only led older children to predict the sunk cost bias. However, it could be that children normally think about waste without using that word per se.

### **Culture and Experience**

The findings in this dissertation suggest that sunk cost predictions develop gradually. Children first grasp how sunk costs lead to consequences like waste and negative emotion, and only later integrate these factors into their predictions of others' actions. What might account for this developmental change? One possibility is young children may not understand that people have limited effort or time, and may not see these as depletable resources. If so, past losses of effort and time might seem irrelevant to children in choices between objects. On this account, spontaneous sunk cost predictions might emerge as children come to view effort and time as limited resources. This account might predict that sunk cost predictions will be sensitive to cultural and economic variations. Children from lower socioeconomic households might learn earlier on that resources should be budgeted and conserved. Scarcity leads people to interpret everyday experiences as involving costs (Shah et al., 2018), and recalling experiences of scarcity compels children and adults to conserve more resources (Ahl et al., 2024; Roux et al., 2015). There is some evidence that thinking about budgeting directly affects sunk cost reasoning—adults with lower childhood SES are more biased by sunk costs than those with higher childhood SES as they perceive sunk costs as wasteful (Jhang et al., 2022). This is because people who grow up in resource-scarce environments cannot tolerate unexpected loss to the same extent as

those in resource-rich environments, and so over time develop a preference to minimize any chance of loss (Amir et al., 2018).

Children may learn how to budget their effort, time, and resources over time (see Webley & Lea, 1993). Children are gradually exposed to messaging about managing resources effectively, both directly through instruction and by observing others' behaviors (Clark et al., 2005; Danes, 1994; Gudmunson & Danes, 2011; Jorgensen & Savla, 2010; Kamber et al., 2024). For instance, parents and teachers help children learn about budgeting as they oversee children's activities and model how children should allocate effort. Children might be explicitly told, "If you spend too much time on this, then you won't have time to do that", or "It's too bad that it didn't work because we worked so hard on it". This messaging might be more common in later childhood as parents start discussing economic behaviors like budgeting, saving, and allowances (e.g., Danes, 1994; Furnham, 1999; Gudmunson & Danes, 2011; Warton & Goodnow, 1995; for a review, see Kamber et al., 2024).<sup>20</sup> These experiences may expose children to deliberate trade-offs between costs and rewards, and they come to feel a loss when effort and time return little reward. When faced with losses, then, children feel they can cope with them if they can frame their costs as not wasted—they find their future actions diminish the burden of loss. As they develop into adolescents and adults, people are led to erroneously see actions as avoiding loss.

Culture may also influence how children value time and effort. Some cultures have more strongly held beliefs about avoiding wastefulness (Inglehart et al., 2014; Mintz et al., 2019; see also Gammoh et al., 2019), and are less tolerant for wasting time and effort as they emphasize the importance of punctuality and productivity (Allen et al., 2025; Brislin & Kim, 2003; Bellezza

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<sup>20</sup> Parents and caregivers might avoid discussing these concepts with younger children as they might not understand or benefit from these discussions yet. Corpus analyses of parent-child and teacher-student conversations could identify when and how children are first exposed to budgeting and explicit cost-reward trade-offs.

et al., 2017).<sup>21</sup> These cultural norms may lead to people seeing time and effort as valued resources that can be wasted and lost. Cultures also vary in their use of currency and practices of exchange and resource tracking, which could lead to differences in how people budget and track mental accounts. Broadly consistent with this, some work suggests mental accounting is shaped by cultural factors. People from Eastern cultures have a more flexible mental accounting system than those from Western cultures due to their holistic thinking style (Banerjee et al., 2019), where accounts are more permeable to gains and losses. One avenue for future work is to further examine sunk cost predictions across cultures. Only one study tested cultural differences, finding that sunk cost predictions were stronger in individualist cultures (Yoder et al., 2014), though, this conclusion is limited because this study only compared Americans and Indians. Future work on cultural influences could uncover the extent to which experience with budgeting and managing mental accounts contributes to sunk cost reasoning.

### **Connection to Theory of Mind**

My experiments tested sunk cost predictions in hypothetical vignettes where children predicted agents' choices between objects. These studies did not test whether children themselves are biased by sunk costs as they did not examine children's own choices in real-world scenarios. Likewise, most research with adults examines sunk cost predictions in hypothetical vignettes (e.g., Arkes & Blumer, 1985; Bornstein & Chapman, 1995; Dijkstra & Hong, 2019; Garland, 1990; Klaczynski, 2001; Olivola, 2018; van Putten et al., 2010), finding that people typically predict that they themselves and others would be biased by sunk costs. However, there is mixed evidence that people honor sunk costs in real-world choices (e.g.,

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<sup>21</sup> Even children may be attuned to values about waste, as suggested by findings that children from WEIRD cultures (Western, Educated, Industrialized, Rich, and Democratic) are more willing to waste resources than children from non-WEIRD cultures (Choshen-Hillel et al., 2019; Zhang & Benozio, 2021).

Cunha & Caldieraro, 2009; for a meta-analysis, see Roth et al., 2015). Some behavioral studies find that the bias is unreliable (Friedman et al., 2007) or even find the reverse effect (Negri et al., 2022). This suggests that *predicting* the sunk cost bias involves different reasoning than the *actual* bias by sunk costs in real life (Devoto & DeFulio, 2022), and supports the use of hypothetical vignettes to examine children’s reasoning about sunk costs.

Predicting choices in sunk cost scenarios may therefore require theory of mind—the understanding that actions are shaped by mental states such as intentions, desires, beliefs, perceptions, and emotions (e.g., Wellman, 2018). Theory of mind guides predictions about both the self and others by reasoning about how mental states lead to actions (e.g., Gopnik & Astington, 1988; Sobel, 2023; see also Buckner & Carroll, 2006)—just as people predict someone will grab an umbrella if they believe it will rain, they predict that they themselves would grab an umbrella if they held that same belief. Seen this way, children’s failure to anticipate that others would be biased by sunk costs suggests late development of some aspects of theory of mind—possibly, for instance, the late development of the understanding that people’s choices depend on prior investments. However, children’s predictions were influenced by considerations of waste and negative emotion, suggesting they see these as factors influencing choice.

Alternatively, these tasks might not tell us anything about theory of mind. One possibility is that children predict agents’ choices based on their observations about how people typically behave. However, it is unlikely that children’s past observations could guide their predictions in my scenarios. After all, choices between identical objects with varying sunk costs are relatively rare, and so children probably have not observed these kinds of choices. Another possibility is that children predict others’ choices by simulating what they would do if faced with the same

choice themselves (e.g., Gordon, 1986; Harris, 1992). For instance, a child might see no difference between the objects and do not have any strong predictions about which they would keep. Yet even this could still involve theory of mind, as it requires children to predict their own mental states in hypothetical scenarios and how these mental states shape their choice.

Future work could examine whether children are biased by sunk costs in their own choices. For example, children could invest varying amounts of effort into identical objects and later choose between them. Children might make biased choices in first-person scenarios because they may be sensitive to their own effort (e.g., Benozio & Diesendruck, 2015; Marsh et al., 2018) and have direct access to their own negative emotions and thoughts about waste. This would suggest that children's inability to predict the sunk cost bias reflects a failure of their theory of mind—while sunk costs influence their own choices, they are unaware that others will be similarly affected by prior investments. Conversely, if children are not biased by sunk costs in their own choices, this would suggest their failure to predict the bias is not a limitation of theory of mind but rather a broader constraint in recognizing actions as avoiding loss.

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## Appendix A: Supplemental Analyses for Chapter Three

### Experiment 2 Exclusions Analysis

Our preregistered exclusion criteria led to a relatively high exclusion rate in Experiment 2 ( $N = 14$ ). However, retaining data from excluded children in the analysis does not impact the results (see Figure S1). There was still an interaction between condition and age,  $F(1) = 6.06$ ,  $p = .014$ , and a main effect of condition,  $F(1) = 45.38$ ,  $p < .001$ . However, the main effect of age was no longer significant,  $F(1) = 3.72$ ,  $p = .054$ .

In following-up on the interaction, there was still no effect of age in the sad condition,  $p = .683$ , with children mostly predicting the boy would be sadder about the high-cost toy,  $CI_{95\%} [0.61, 0.75]$ . There was also still an effect of age in the fix condition,  $p = .004$ , as older children were more likely than younger ones to predict the boy will fix the low-cost toy. Responses first fell below chance (toward the low-cost toy) at the same age: 5;8,  $CI_{95\%} [0.33, 0.48]$ . Responses in the sad and fix conditions first diverged at age 5;4; sad judgment,  $CI_{95\%} [0.56, 0.75]$ ; fix judgment  $CI_{95\%} [0.36, 0.55]$ .

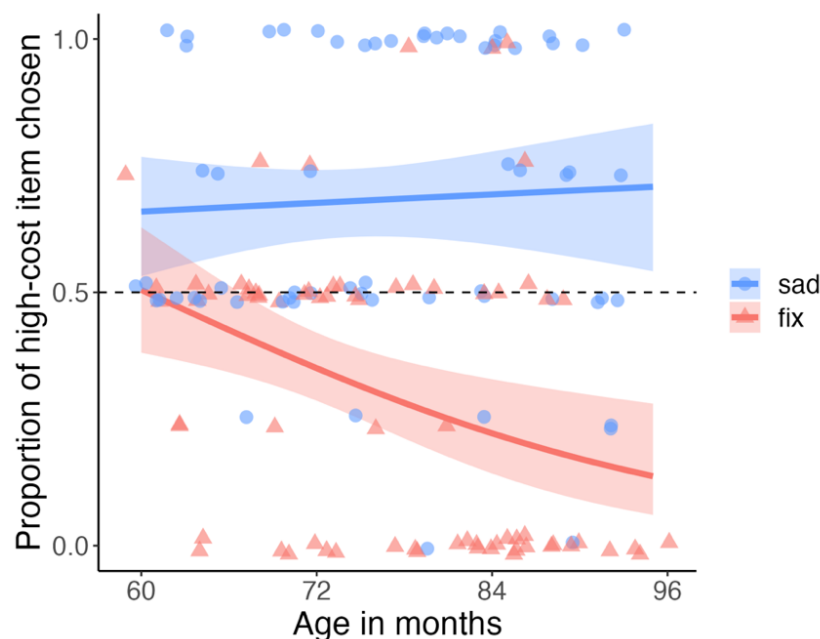


Figure S1. Results for Experiment 2 including data from excluded children ( $N = 14$ ).

## Experiment 2 Additional Action Predictions

In Experiment 2, adults predicted that the character would feel sadder about the high-cost object but would fix the high- and low-cost objects at equal rates. This lack of sunk cost effect in the action prediction raises the question of whether the scenario involved considerations about sunk costs at all. We conducted the following supplemental experiment examining two other action predictions in this scenario: which object the character will keep, and which object the character will play with.

Furthermore, we manipulated whether the toys were broken or intact. The lack of sunk cost effect in Experiment 2 could have resulted from people reasoning about broken objects differently than reasoning about intact objects, such as in Experiment 3 where adults considered sunk costs when predicting action.

### Method

**Participants.** We tested 388 adults ( $M_{\text{age}} = 42.41$ , range = 20-92, 178 female, 206 male, 4 other/unspecified). An additional 24 adults were tested but excluded due to our preregistered exclusion criteria.

**Procedure.** Participants saw similar stimuli to Experiment 2. But this time, participants were randomly assigned to a condition across two between-subjects factors. The first between-subjects factor manipulated the action prediction: participants were either asked which toy the boy will keep, or which toy the boy will play with. The other between-subjects factor manipulated whether the toys were broken (like Experiment 2) or intact (like Experiment 3).

### Results

Participants' responses did not differ across action prediction,  $F(1) = 1.96$ ,  $p = .161$ , nor did they differ whether the objects were broken or intact,  $F(1) = 1.61$ ,  $p = .205$ . There was also

no interaction between these factors,  $F(1) = 1.41, p = .236$ . A single-sample test against chance revealed that adults mostly predicted the boy would select the high-cost toy (60% of responses),  $p < .001$ .

### **Experiment 2 Exploratory Analysis**

We wondered whether asking about the character's sadness impacts children's prediction of which object the character will fix. To examine this, on the last trial in the sadness condition, children were asked about which item the character would fix. We then compared this "prompted" fix judgment with the final judgment given by children who were only asked about fixing (i.e., those assigned to the fix condition, see Figure S2). Age in months (mean-centered) was entered as a covariate, with judgment (fix, exploratory fix) as a between-subjects factor. There was a main effect of judgment, as children were more likely to select the low-cost toy in the fix condition (i.e., when they had not previously judged sadness) than in the prompted fix question (i.e., when they had previously judged sadness),  $F(1) = 7.58, p = .006$ . There was no effect of age,  $F(1) = 1.76, p = .185$ , and no significant interaction between judgment and age,  $F(1) = 2.92, p = .088$ . In sum, although asking about emotions appeared to affect fixing judgments, this did not bring children to predict the character would honor sunk costs and preferentially repair the high-cost object.

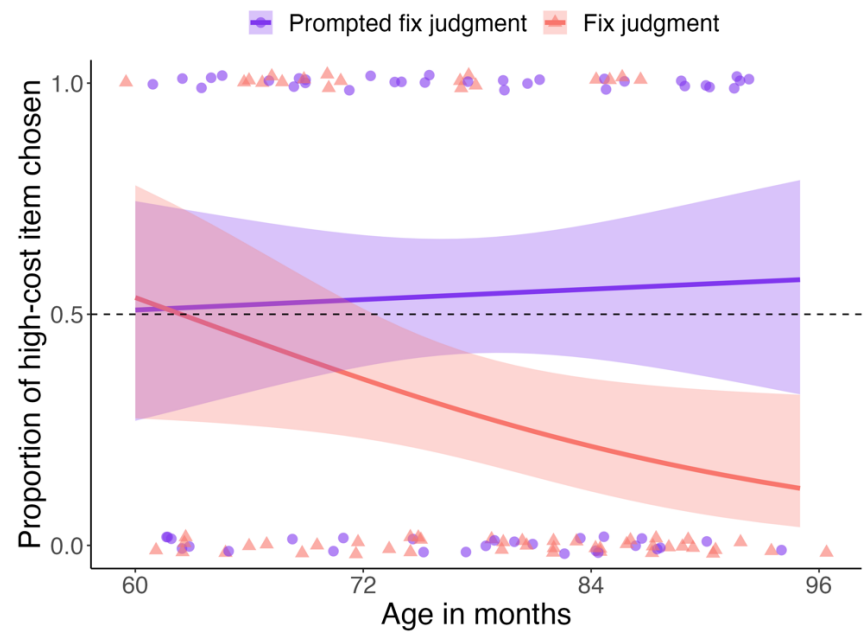


Figure S2. Results for fix judgments versus prompted fix judgments in Experiment 2.

## Appendix B: Response Rates to Prompts in Chapter Four

Below we report the percent of trials that children passed the prompt on their first try, and on their second try across prompting conditions. See Table S1 for the number of trials retained and excluded for each prompt across experiments.

*Table S1.*

Number of trials retained and excluded for each prompt across experiments.

|                     | Passed prompt<br>first try (retain) | Passed prompt<br>second try (exclude) | Failed prompt<br>second try<br>(exclude) | Total<br>trials |
|---------------------|-------------------------------------|---------------------------------------|------------------------------------------|-----------------|
| <b>Experiment 1</b> |                                     |                                       |                                          |                 |
| Sad                 | 90                                  | 19                                    | 11                                       | 120             |
| Effort              | 116                                 | 4                                     | 0                                        | 120             |
| Control             | 115                                 | 3                                     | 2                                        | 120             |
| <b>Experiment 2</b> |                                     |                                       |                                          |                 |
| Waste               | 110                                 | 15                                    | 1                                        | 126             |
| Effort              | 118                                 | 3                                     | 1                                        | 122             |
| Control             | 117                                 | 3                                     | 0                                        | 120             |
| <b>Experiment 3</b> |                                     |                                       |                                          |                 |
| Waste               | 55                                  | 15                                    | 10                                       | 80              |
| Effort              | 80                                  | 0                                     | 0                                        | 80              |
| Control             | 79                                  | 1                                     | 0                                        | 80              |

### Experiment 1

On their initial response, children passed the sad prompts on 75% of the trials, the effort prompt on 97% of the trials, and the control prompt on 95% of the trials. After repeating the story and prompting again, this rate rose to 91% for the sad prompt, 100% for the effort prompt, and 98% for the control prompt. The confidence intervals for the sad prompt confirm that these responses are above chance even from age 5;0; sad  $CI_{95\%}$  [0.69, 0.95].

### Experiment 2

On their initial response, children passed the waste prompts on 87% of the trials, the effort prompt on 97% of the trials, and the control prompt on 98% of the trials. After repeating

the story and prompt again, this rate rose to 99% for the waste prompt, 99% for the effort prompt, and 100% for the control prompt.

### **Experiment 3**

On their initial response, children passed the waste prompts on 69% of the trials, the effort prompt on 100% of the trials, and the control prompt on 99% of the trials. After repeating the story and prompt again (i.e., on their second try), this rate rose to 88% for the waste prompt and 100% for the control prompt.

## Appendix C: Supplemental Exclusions Analyses for Chapter Four

### Exclusions analysis

We investigated whether children's action predictions were influenced by the responses of children who did not pass the prompt on their first attempt. The prompting procedure allowed children two opportunities to answer the question; if they failed both times, the experimenter provided the correct answer and proceeded to the "keep" question. To explore this further, we re-analyzed the data from each experiment, focusing only on children who answered the prompt correctly on their first try. While the results of the GEE analyses did not differ, some follow-up comparisons did, and these differences are noted below. It is important to interpret these results with caution, as excluding data reduced the sample size and limited the statistical power to detect differences. See Figure S3 for children's responses to action prediction questions across Experiments 1-3, including only data from participants who initially passed the prompt question.

**Experiment 1.** The age by condition GEE revealed a main effect of age,  $\chi^2(1) = 11.23$ ,  $p < .001$ , as older children were more likely to select the high-cost object than younger children. There was also a main effect of condition,  $\chi^2(2) = 3.87$ ,  $p = .022$ . Bonferroni-corrected pairwise comparisons revealed that children were more likely to select the high-cost object in the effort condition than the control condition,  $p = .022$ . However, children's responses in the sad condition never differed from the effort or control conditions  $ps \geq .440$ . There was no interaction between condition and age,  $\chi^2(2) = 1.00$ ,  $p = .368$ . Single-sample tests showed children's responses in the effort condition differed from chance,  $p = .003$ , and responses went above chance by age 6;1,  $CI_{95\%} [0.52, 0.75]$ . However, responses did not differ from chance in the sad condition,  $p = .169$ , or the control condition,  $p = .483$ .

**Experiment 2.** The age by condition GEE revealed a main effect of age,  $\chi^2(1) = 5.50, p = .020$ , as older children were more likely to select the high-cost object than younger children. There was also a main effect of condition,  $\chi^2(2) = 3.10, p = .046$ . Bonferroni-corrected pairwise comparisons revealed no significant differences between conditions,  $ps \geq .060$ . There was also an interaction between condition and age,  $\chi^2(2) = 5.29, p = .006$ . This interaction resulted because choices of the high-cost object increased with age in the effort condition,  $p < .001$ , but were not affected by age in the waste or control conditions,  $ps \geq .450$ . In the effort condition, children first chose the costly item at rates exceeding chance at age 6;7,  $CI_{95\%} [0.51, 0.75]$ . Single-sample tests showed responses did not differ from chance in any condition; waste  $p = .074$ , effort  $p = .152$ , control,  $p = .385$ .

**Experiment 3.** The age by condition GEE revealed a main effect of age,  $\chi^2(1) = 6.87, p = .009$ , as older children were more likely to select the high-cost object than younger children. There was also a main effect of condition,  $\chi^2(2) = 8.17, p < .001$ . Bonferroni-corrected pairwise comparisons revealed that children were more likely to select the high-cost object in the effort condition than the control condition,  $p < .001$ . However, children's responses did not differ from the waste condition than the effort condition,  $p = .570$ , or the control condition,  $p = .116$ . There was no interaction between condition and age,  $\chi^2(2) = 1.77, p = .174$ .

The 95% confidence intervals show that children selected the high-cost object above chance in the waste condition by age 6;11,  $CI_{95\%} [0.53, 0.84]$ , and across all ages in the effort condition  $CI_{95\%} [0.73, 0.91]$ . Responses in the control condition never differed from chance,  $CI_{95\%} [0.37, 0.62]$ . Results from single-sample tests yield a similar interpretation. Children in the waste condition chose the high-cost object marginally above chance,  $p = .050$ , and children in the

effort condition chose it above chance,  $p < .001$ . Children's responses in the control condition did not differ from chance,  $p = .922$ .

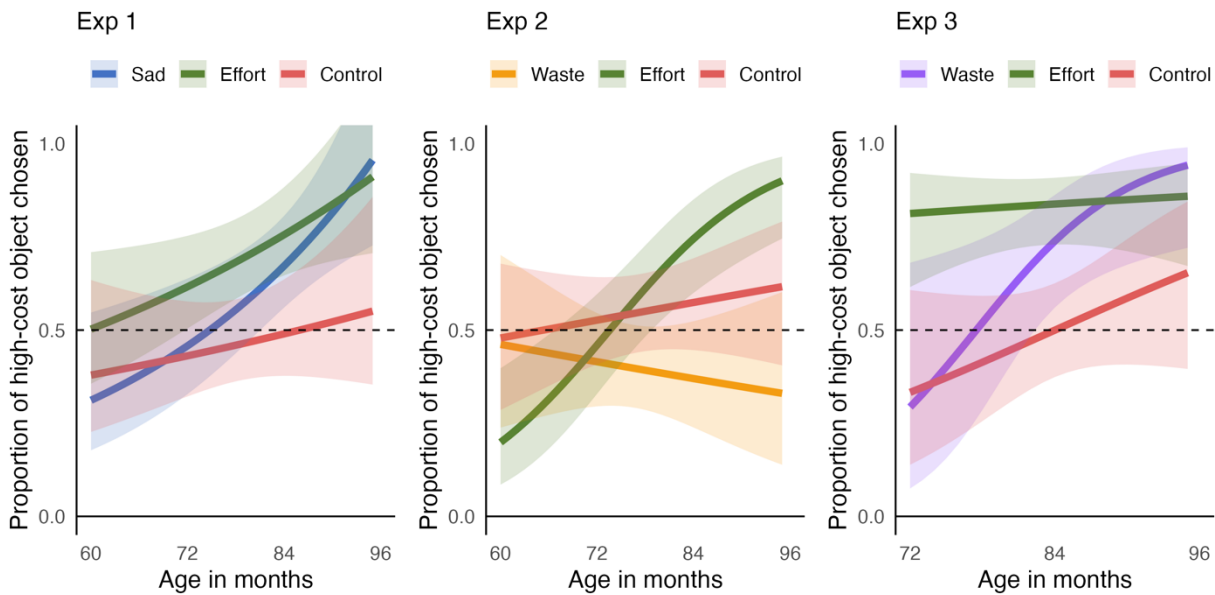


*Figure S3.* Children's responses to action prediction questions across Experiments 1-3, including only data from participants who initially passed the prompt question.