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Authors

Kramer, Hannah J
Goldfarb, Deborah
Tashjian, Sarah M
[et al.](#)

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“These Pretzels are Making Me Thirsty:” Older Children and Adults Struggle with Induced-State Episodic Foresight

Hannah J. Kramer, Deborah Goldfarb, Sarah M. Tashjian, and Kristin Hansen Lagattuta

University of California, Davis

Abstract

We explored children’s and adults’ ability to disengage from current physiological states when forecasting future desires. In Study 1, 8- to 13-year-olds and adults ($N=104$) ate pretzels (to induce thirst) and then predicted and explained what they would want tomorrow, pretzels or water. Demonstrating lifespan continuity, approximately 70% of participants, regardless of age, chose water and referenced current thirst as their rationale. Individual differences in working memory and undergraduate GPA were positively related to performance on the pretzel task. In Study 2, we obtained baseline preferences from adults ($N=35$) and confirmed that, prior to consuming pretzels, people do not anticipate wanting water more than pretzels the next day. Together, these findings indicate that both children and adults are tethered to the present when forecasting their future desires.

The ability to imagine oneself at a specific time in the future (*episodic foresight*, EpF) is a major developmental milestone (Atance & O’Neill, 2001). Although there is substantial growth within early childhood (Atance, 2015), even adults have difficulty future forecasting. That is, when adults engage in *induced-state EpF*—thinking about the future while experiencing a highly salient current state—they weight their present circumstances too heavily (Wilson & Gilbert, 2003). Because researchers have yet to compare children and adults on induced-state EpF tasks, it remains an open question whether there is developmental change versus continuity in how people forecast the future when biased by present states (Kramer & Lagattuta, in press). Bridging developmental and adult literatures, we explored potential age-related changes in induced-state EpF. We also investigated sources of individual differences in EpF as well as how EpF links to success in everyday decision making.

There are improvements within childhood and between childhood and adulthood in non-induced state EpF (e.g., Atance, 2015; Lagattuta, 2014). For example, Atance, Louw, and Clayton (2015) had preschoolers play in two rooms, one with toys and one without them. Children were then told that they could put toys in one room to play with the next time they visited. Four- and 5-year-olds chose the “no toy room” presumably because they knew that this would give them something to do. Three-year-olds did not make this advantageous

Correspondence concerning this article should be addressed to Hannah J. Kramer, Department of Psychology and Center for Mind and Brain, University of California, Davis, 1 Shields Avenue, Davis, CA 95616. may be sent to hjkramer@ucdavis.edu.
Hannah J. Kramer, Deborah A. Goldfarb, Sarah M. Tashjian, and Kristin Hansen Lagattuta Department of Psychology and Center for Mind and Brain, University of California Davis.

decision. These findings parallel a number of studies where 4- and 5-year-olds engage in EpF, but 3-year-olds do not (e.g., Russell, Alexis, & Clayton, 2010; Suddendorf, Nielsen, & von Gehlen, 2011).

Despite age-related changes in EpF, problems with induced-state EpF persist into adulthood. For instance, while there is development in preschoolers' understanding that their preferences will change as they grow (Belanger, Atance, Varghese, Nguyen, & Vendetti, 2014), even adults have difficulty recognizing that what they like now differs from what they will prefer in the future (Quoidbach, Gilbert, & Wilson, 2013; Reoumlt, Kopp, Davidson, Taler, & Atance, 2016). Relatedly, despite preferring pretzels to water prior to eating them, 3- to 7-year-olds anticipate wanting water tomorrow, apparently because they are currently thirsty (Atance & Meltzoff, 2006; Mahy, 2015; Mahy, Grass, Wagner, & Kliegel, 2014). Again, although this seems like an error confined to early childhood, adults forecast similarly. Thirsty adults (compared with non-thirsty adults) more often think that another person (who is hungry and thirsty) will want water more than food (Van Boven & Loewenstein, 2003).

Given the extant literature, it seems possible—if not likely—that current states influence future forecasts to a similar extent across the lifespan. To our knowledge, we are the first to examine this hypothesis systematically. Eight- to 13-year-olds and adults ate pretzels and then predicted what they would want tomorrow, pretzels or water. Using an existing task allowed for a more complete developmental interpretation as we can compare our sample to 3- to 7-year-olds' responses in previous research (Atance & Meltzoff, 2006; Mahy, 2015; Mahy et al., 2014).

Because prior work has shown that some participants (approximately 30%) can disregard current states when imagining the future, we also examined potential sources of individual variability, inhibitory control (IC, stopping dominant responses, Best & Miller, 2010) and working memory (WM, tracking and manipulating multiple pieces of information, Baddeley, 1992). These cognitive abilities are hypothesized to contribute to EpF (Suddendorf & Corballis, 2007). We reasoned that people would recruit IC to suppress choosing in accord with current desires (Carlson, Davis, & Leach, 2005) and WM would aid individuals in shifting between the current moment and a future one (Lagattuta, Sayfan, & Blattman, 2010; Lagattuta, Sayfan, & Harvey, 2014). Hanson, Atance, and Paluck (2014) found no IC-EpF or WM-EpF links in 3- to 5-year-olds. These authors, however, did not examine induced-state EpF. Given that induced-state EpF is more difficult as indicated by the lack of development in early childhood (Atance & Meltzoff, 2006; Mahy, 2015; Mahy et al., 2014), it may require a higher threshold of IC and WM not yet developed in preschoolers. IC and WM continue to develop into adulthood (Conklin, Luciana, Hooper, & Yarger, 2007; Kramer, Lagattuta, & Sayfan, 2015; Lagattuta, Sayfan, & Monsour, 2011; Williams, Ponesse, Schacher, Logan, & Tannock, 1999); therefore, the IC- and WM-EpF links may rely on higher levels of executive function not attained by 3 to 5 years of age. Thus, investigation into IC-EpF and WM-EpF connections in older individuals is necessary.

Although there is a general consensus that EpF abilities should predict superior decision making, little research has addressed this question (Boyer, 2008). Recently, however,

Bromberg, Wiehler, and Peters (2015) demonstrated that individuals who are better at envisioning the future are more likely to forego smaller but immediate rewards for larger delayed ones. Here, we examine the link between induced-state EpF and undergraduate grade point average (GPA)—a proxy for decision making outside of the laboratory setting. Even when accounting for IQ, adolescents who show greater self-discipline earn higher grades than those who do not (Duckworth & Seligman, 2005). Thus, individuals with higher GPAs likely better weight their current desires against the future effects of their present decisions (e.g., considering tomorrow's test when choosing to study or socialize) and modify their behavior accordingly.

In summary, we had three aims: (1) To bridge the developmental and adult literatures on induced-state EpF; (2) To elucidate potential mechanisms that allow some people to override current states when imagining their future self; and (3) To examine whether induced-state EpF skills benefit young adults' decision making.

Study 1

We administered the pretzel task (Atance & Meltzoff, 2006) to 8- to 13-year-olds and adults. We hypothesized that across age participants would struggle to disregard their current thirst when forecasting their future desires. We also assessed developmental changes in choice explanations. Mahy (2015) found that thirsty 3- to 7-year-olds could not explain why they prefer water for tomorrow. Because metacognitive awareness develops within childhood (e.g., Flavell, Green, & Flavell, 1995; Lagattuta & Sayfan, 2011), we anticipated that our older sample would be more cognizant of what drives their future-oriented choices. We further examined IC and WM as potential sources of individual differences that would allow some people to overcome current states when engaging in induced-state EpF. To understand the benefits of induced-state EpF, we investigated the link between GPA and the pretzel task. We anticipated that those who were better able to overcome their present states in the pretzel task would have higher GPAs.

Method

Participants—Eighty-nine 8- to 13-year-olds and adults were divided into 3 age groups: 30 9-year-olds ($M = 9.73$ years, $SD = .97$ year, range = 8.03–10.98; 17 females), 26 12-year-olds ($M = 12.18$, $SD = .76$, range = 11.01–13.27; 14 females), and 33 adults ($M = 22.15$, $SD = 3.92$, range = 19.43–41.07; 17 females). Additional participants were excluded due to experimenter error (1 9-year-old, 1 adult), refusal to eat pretzels or hatred for pretzels (2 12-year-olds, 4 adults), and failure to induce thirst via self-report (2 9-year-olds, 3 12-year-olds, 2 adults). Children were recruited from a database of previous research participants, advertisements, local farmers' markets, and participant referrals. Adults were recruited from the undergraduate participant pool at a public 4-year university. All included participants were fluent in English. Of the child participants, 77% were Caucasian, 4% Hispanic, 2% Asian, and 18% of mixed ethnic or racial heritage. Of the adult participants, 18% were Caucasian or of European descent, 18% Hispanic, 42% Asian, and 21% other or of mixed ethnic or racial heritage. Eighty percent of child participants had at least one parent with a college degree.

Materials and procedures

Induced-state EpF: We adapted the pretzel task from Atance and Meltzoff (2006). Children and adults were given 30 pretzel sticks (approximately one serving size) and encouraged to eat as many as they wanted during a 5-minute “break” period. Participants were then told: “Let’s pretend that you’re coming here tomorrow to do some more activities and that we will take another break. What do you think you would like during the break tomorrow, some pretzels to eat or some water to drink?” Order of presentation of choices (pretzels or water) was counterbalanced (pretzels-first condition = 43; water-first condition = 46). Participants were shown pictures of the options. Children and adults also explained their choice and rated their thirst from 0 to 3 (0 being *not at all thirsty* and 3 being *very thirsty*). Participants’ choices were dummy coded. Explanations were coded for the presence of thirst, and then for whether the reference was explicit (e.g., “Because I’m thirsty”) or implicit (e.g., “The pretzels make my throat dry”). Two coders coded 100% of the data with excellent reliability (.81 > κ s > .89). Disagreements were reconciled by discussion.

Inhibitory control: Participants completed *happy-sad* as a measure of IC, shown to be appropriate for this wide age range (Kramer et al., 2015; Lagattuta et al., 2011). Participants were instructed to label each picture with the opposite name (e.g., say ‘happy’ to sad faces). Participants repeated the rules and performed four practice trials at 100% accuracy before proceeding to 20 test trials. Error rates were used for scoring purposes. Responses were scored as correct if the opposite label was given as the first utterance; self-corrections (e.g., “happy, no sad”) were incorrect. An independent coder counted errors; a second coder scored 30% of the sample; agreement within +/- 1 error was 92%.

Working memory: Participants completed *Memory for Sentences* as a test of WM (Stanford-Binet: Fourth Edition; Thorndike, Hagan, & Sattler, 1986). The experimenter read sentences aloud and participants were instructed to repeat each sentence verbatim. Initial sentences were selected based on the participant’s age and grew in length and complexity as the task progressed. Participants’ scores were calculated according to established standards.

Undergraduate GPA: Adults self-reported their cumulative GPA. We did not obtain official records, but self-reported GPA strongly correlates with actual GPA (Cassady, 2001).

General Procedure: Female experimenters tested participants individually in a quiet room. All participants completed the tasks in the same order: induced-state EpF, IC, and WM. This study was part of a larger investigation on EpF. Participants’ predictions for the current study were always first. Children received a gift valued at less than \$5.00; adults received course credit. Sessions lasted approximately 30 min. Data were collected July through December 2014.

Results and Discussion

Results are presented in five sections. First, we conducted preliminary analyses of the relation between number of pretzels consumed, presentation of choice, sex, and ethnicity and participants’ choices for tomorrow. Next, we explored age-related changes in choices.

Third, we analyzed participants' explanations. Fourth, we investigated IC-EpF and WM-EpF links. Finally, we tested the predictive power of EpF on undergraduate GPA.

Preliminary Analyses—Tables 1 and 2 demonstrate means and correlations. Number of pretzels consumed did not differ by age ($R^2 = .02$, $F(1, 87) = .03$, $p = .87$, $b = .03$, $\beta = .02$). Total pretzels consumed ($Wald = .09$, $Exp(B) = 1.01$, $p = .77$), order of presentation (pretzel-first or water-first, $\chi^2(1) = .46$, $p = .50$), sex ($\chi^2(1) = 1.33$, $p = .25$), and ethnicity (Caucasian versus not Caucasian, $\chi^2(1) = 1.03$, $p = .31$), were unrelated to anticipated future choice.

Primary Analyses

Developmental trajectory of induced-state EpF: We conducted a logistic regression with age (continuous) as the predictor and choice as the dependent variable. As shown in Figure 1, age did not predict choices ($Wald = .09$, $Exp(B) = 1.01$, $p = .77$).

Explanations of induced-state EpF: Of the 69 participants who chose water, 81% referenced thirst (of those, 39% did so explicitly, e.g., “I’m thirsty”). In contrast, only 10% of “pretzel choosers” referenced thirst. The tendency to refer to thirst did not change with age ($Wald = .08$, $Exp(B) = .99$, $p = .78$). Table 3 provides example explanations. Participants' simulations may only be faulty if water is explained in terms of thirst. We recoded the data so that participants were “correct” if they chose pretzels or if they chose water but never (explicitly or implicitly) mentioned thirst. Despite this recoding, age was still unrelated to choices ($Wald = .002$, $Exp(B) = .002$, $p = .96$). Thirty percent of 9-year-olds, 46% of 12-year-olds, and 36% of adults selected pretzels or chose water for a reason other than their current thirst.

Individual differences in induced-state EpF

Inhibitory control: With age, participants erred less often ($R^2 = .20$, $F(1, 87) = 21.36$, $p < .001$, $b = -.17$, 95% CI[-.25, -.10], $\beta = -.44$). A logistic regression controlling for age ($Wald = .09$, $Exp(B) = 1.01$, $p = .77$) revealed that IC ($Wald = .30$, $Exp(B) = 1.07$, $p = .59$) was unrelated to choices. There was no significant Age x IC interaction ($Wald = .05$, $Exp(B) = 1.00$, $p = .82$).

Working memory: With age, participants demonstrated stronger WM ($R^2 = .09$, $F(1, 87) = 8.66$, $p = .004$, $b = .17$, CI[.06, .29], $\beta = .30$). A logistic regression controlling for age ($Wald = .09$, $Exp(B) = 1.01$, $p = .77$), revealed that participants with better WM were more likely to choose pretzels ($Wald = 4.66$, $Exp(B) = 1.20$ CI[1.02, 1.40], $p = .031$). There was no significant Age x WM interaction ($Wald = 1.23$, $Exp(B) = 1.01$, $p = .27$).

Undergraduate GPA: One male participant did not report his GPA and was excluded. GPA was positively correlated with choices (Table 2). We conducted a hierarchical linear regression on academic performance with working memory entered first and then induced-state EpF. Both models were significant (Model 1: $F(1, 30) = 5.25$, $p = .029$; Model 2: $F(2, 29) = 5.51$, $p = .009$): Better induced-state EpF ($R^2 = .28$, $R^2 = .13$, $p = .032$, $b = .49$, CI[.

04, .94], $\beta = .41$) predicted higher academic performance even after controlling for differences in WM ($R^2 = .15$, $p = .029$, $b = .05$, CI [.01, .09], $\beta = .39$).

Study 2

Study 1 suggests that disengaging from current states to forecast future desires is difficult across age. Work with children indicates a strong baseline preference for pretzels over water (Atance & Meltzoff, 2006; Mahy, 2015). In Study 2 we tested whether adults share this baseline desire. This provides an important control to aid in interpreting and bolstering the findings from Study 1: When not thirsty, what do adults prefer for the future? In Study 2, we compared the forecasted preferences of thirsty adults (Study 1) to a new sample of non-thirsty adults. We chose a between-subjects design because asking adults for their baseline preference, giving them pretzels, and asking what they would want tomorrow (with one of the two choices being pretzels) likely would reveal the study's purpose.

Method

As an optional after-class activity, 32 undergraduates (23 females) predicted and explained whether they would want pretzels or water at the same time the next day (without thirst induction). Adults were shown pictures of the options (same pictures as shown in Study 1). They then anonymously recorded their choice and rationale on paper. Three additional adults were surveyed but excluded due to an explicit hatred of pretzels (same criteria as Study 1). Although no identifying information was obtained from this sample, participants were drawn from the same population as Study 1. Two coders coded 100% of the water-choosers' explanations for presence of thirst (implicit or explicit), and reliability was excellent ($\kappa = .82$). Disagreements were reconciled by discussion. Data were collected August 2015.

Results and Discussion

Of those surveyed, 66% chose pretzels for tomorrow. This percentage differed marginally from chance ($t(31) = 1.83$, $p = .077$). Thus, at baseline, adults do not anticipate wanting water more than pretzels the next day. We tested whether eating pretzels changes forecasting: Thirsty adults (Study 1, 21%) were less likely to choose pretzels for tomorrow than non-thirsty adults (Study 2, 66%; $\chi^2(1) = 13.07$, $p < .001$). Non-thirsty adults (Study 2) also chose pretzels or picked water for a reason other than thirst (e.g., "Because water is healthier") more frequently (81%) than the adults from Study 1 (36%; $\chi^2(1) = 13.48$, $p < .001$).

Study 2 supports the conclusion that people allow current states to influence their future desires. Non-thirsty adults show no preference for water over pretzels for tomorrow. Non-thirsty adults anticipate preferring water the next day at one-third the rate of thirsty adults.

General Discussion

The current research documents lifespan continuity: Like 3- to 7-year-olds (Atance & Meltzoff, 2006; Mahy, 2015; Mahy et al., 2014), 8- to 13-year-olds and adults struggle with induced-state EpF. Approximately 70% of pretzel-eating participants forecasted that they would want water tomorrow and referred to their present thirst to explain this decision. Even

with less stringent scoring criteria—counting it as correct to choose water for tomorrow as long as this choice was not rationalized in terms of current thirst—age effects were null, with the majority of children and adults showing errors in logic. This rate of anticipating a future water preference is significantly higher than participants in a baseline, non-thirsty condition. Despite age invariance, we found evidence for individual differences. Participants with higher WM more often overcame their current thirst to choose pretzels for tomorrow. Moreover, pretzel-choosing adults obtained higher grades in college courses, indicating that induced-state EpF skills can predict success in decision making outside of the lab.

These findings are intriguing given the argument that humans are unique from non-human animals because of the ability to consider future needs when they are currently irrelevant (Bischof-Kohler, 1985; Suddendorf & Corballis, 1997). Mahy (2015) suggested that young children's poor performance on the pretzel task indicates that they may also struggle to project themselves into a future that conflicts with their current state. The present work points to a modified conclusion: It is not that individuals of a certain age cannot think in a future-oriented manner, but rather that specific situations make it more difficult to engage in EpF. That is, across the lifespan, humans struggle to keep the future in mind when current circumstances are overpowering. This may be the case especially for salient physiological states.

Why would physiological states be more problematic? Previous research suggests that the brain prioritizes physiological needs for survival, making it difficult to consider anything else. For example, adults experiencing a deficit of a resource (e.g., water, food, money) show heightened attention to that need. To illustrate, thirst makes water-related words quicker to find (Aaarts, Dijksterhuis, & De Vries, 2001; Anandi, Mullainathan, Shafir, & Zhao, 2013; Radel & Clément-Guillotin, 2012; Shah, Mullainathan, & Shafir, 2012). Future work should explore additional contexts where evolutionarily-advantageous thinking may cause cognitive errors in the absence of actual survival threat. Because thirst may be a particularly salient visceral factor (Loewenstein, 1996), researchers should also investigate whether other physiological conditions (e.g., hunger, temperature) and non-physiological states (e.g., emotions) create as potent of a challenge for future thinking across age. More generally, it would be interesting to examine other cognitive “errors” that may serve an adaptive purpose (Frankenhuis & de Weerth, 2013).

Despite a lack of development in children's and adults' predictions for tomorrow, we found evidence for a developing awareness of the causes of these choices. That is, while most 8- to 13-year-olds and adults in our sample referenced their current thirst as a reason for their decision (no age differences), Mahy (2015) found that 3- to 7-year-olds rarely provided such explanations. These findings fit with a substantial body of work indicating significant gains in metacognitive understanding within childhood (e.g., Flavell et al., 1995). This emerging ability to reflect on why decisions are made is particularly important from an intervention perspective. That is, perhaps an ideal springboard for improving induced-state EpF would be making people more aware of the causes of their disadvantageous choices. Indeed, prior work indicates that explaining a concept leads to a more solid grasp of it (e.g., Amsterlaw & Wellman, 2006; Lombrozo, 2006; O'Reilly, Symons, & MacLatchy-Gaudet). Thus, future research should examine whether individuals who thoughtfully reflect on the rationale for

their choices (either spontaneously or prompted) more often make optimal future-oriented decisions.

As with younger children (Atance & Meltzoff, 2006; Mahy, 2015; Mahy et al., 2014), some 8- to 13-year-olds and adults were better able to engage in induced-state EpF. Consistent with our hypothesis, higher-order cognitive processes supported induced-state EpF (Buckner & Carroll, 2007; Suddendorf & Corballis, 2007). Participants with stronger WM exhibited better EpF. This finding contrasts with recent work by Hanson et al. (2014). They, however, investigated preschoolers performing EpF tasks without induced states. Induced-state EpF requires individuals to coordinate present and future perspectives by considering intervening events that could result in differing current and future physiological states. For example, barring unusual circumstances, participants *will* have the opportunity to drink water during the interim 24-hour period. This should be considered when forecasting the future. Greater WM may facilitate a more accurate simulation, which in turn improves EpF.

Despite an EpF-WM link, IC was unrelated to participants' decisions. This is consistent with recent work demonstrating that IC is unrelated to EpF more generally (Hanson et al., 2014). This finding is further bolstered by the fact that only 1 of 89 participants self-corrected after answering what they would want tomorrow, demonstrating that saying "water" is not an impulsive or prepotent response. It is possible that certain kinds of IC are implicated in some EpF tasks. For example, IC delay tasks requiring participants to discount their current desires to prioritize future rewards (e.g., the marshmallow task; Mischel, Shoda, & Rodriguez, 1989) may be predictive of EpF abilities. In addition, although our sample size was in line with other recent individual differences studies (e.g., Bromberg et al., 2015; Hanson et al., 2014), it may be that our sample was too small to detect the relation between IC and induced-state EpF.

EpF is theorized to be important for everyday decision making (e.g., academic performance, financial decisions, and managing relationships; Boyer, 2008). This assumption, however, has not been systematically tested (see Bromberg et al., 2015). The current data reveal significant connections between EpF skill and real world outcomes: Even when controlling for WM, adults with higher college GPA more often anticipated wanting pretzels for tomorrow despite their current thirst. The strength of this relation approximated the correlation between SAT scores and college GPA as well as high school grades and college GPA (Camara & Echternacht, 2000). Importantly, however, we only assessed this relation in adults. We chose this strategy because until college, academic-related decisions are heavily monitored by parents, and thus would not exclusively reflect a child's ability to engage in deliberate future planning. Future research should examine relations between future-thinking skills and decision making from a developmental perspective; longitudinal approaches would be especially informative.

Conclusion

In conjunction with prior work (Atance & Meltzoff, 2006; Mahy, 2015; Mahy et al., 2014), we demonstrate that setting aside present states when forecasting future desires is not solely a challenge for young children. Using the same induced-state EpF task across a wide age

range, we found that the pass rate of 8- to 13-year-olds and adults (approximately 20–30%) did not improve across age and matched that of previous research with 3- to 7-year-olds. Participants with better WM exhibited superior performance on the induced-state EpF task, indicating that identifying sources of individual differences may provide clues as to the underlying causal mechanisms that support this skill set. Moreover, the link between induced-state EpF and undergraduate GPA demonstrates that improving future-thinking abilities could have positive downstream effects on everyday decision making. Continuing to explore induced-state EpF from a lifespan and individual differences approach will elucidate our understanding of why people so frequently assume that today dictates tomorrow.

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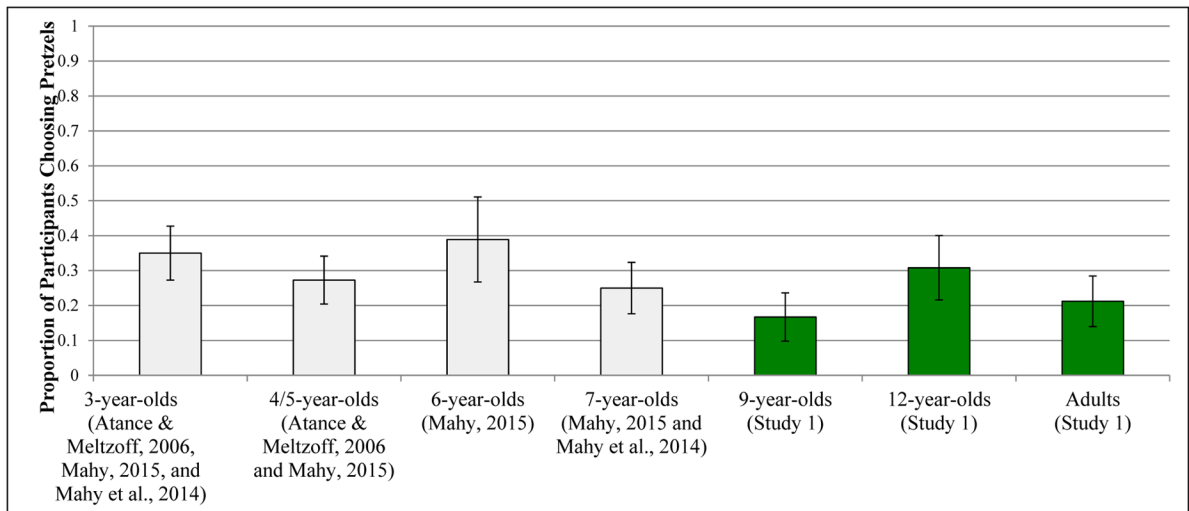


Figure 1. Study 1: Induced-State EpF Performance Across Age

Error bars represent standard errors. Our data, in conjunction with previously collected data (Atance & Meltzoff, 2006; Mahy, 2015; Mahy et al., 2014), demonstrate a lack of development in induced-state EpF.

Table 1

Study 1: Means and Standard Deviations

	9-year-olds (N = 30)	12-year-olds (N = 26)	Adults (N = 33)
Choice	.17 (.38)	.31 (.47)	.21 (.42)
Pretzels Consumed	18.70 (8.11)	19.19 (7.25)	20.52 (9.76)
IC Errors	4.47 (2.61)	3.00 (1.90)	1.76 (1.75)
WM	25.00 (3.30)	26.96 (2.27)	27.73 (3.92)
GPA	--	--	2.90 (.50)

Note. Total possible IC errors = 20; maximum possible score for WM = 42.

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Table 2

Study 1: Bivariate Correlations

	Choice	Age	IC Errors	WM	GPA
Choice	1				
Age	.03	1			
IC Errors	.04	-.44**	1		
WM	.24*	.30**	-.13	1	
GPA	.50**	-.04	-.08	.39*	1

* $p < .05$

** $p < .01$

Table 3

Study 1: Examples of Explanations

Choice	Explanation
Water	“Cause staring at it [the picture of water] makes it look really, really good. Cause I’m thirsty.”
Water	“Because pretzels are really dry”
Water	“Because I’m thirsty right now.”
Pretzels	“I may feel a little bit thirsty right now but [...] if I come back and do the same thing tomorrow, I can be prepared by like having a water-bottle or [...] drinking water before I come here.”
Pretzels	“Because by tomorrow when I come back, I’ll probably be hungry or something and water doesn’t really fill you up.”
Pretzels	“I’ll be hungry by the time I come in.”