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Brief article

Rational snacking: Young children's decision-making on the marshmallow task is moderated by beliefs about environmental reliability

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ABSTRACT

Children are notoriously bad at delaying gratification to achieve later, greater rewards (e.g., Piaget, 1970)—and some are worse at waiting than others. Individual differences in the ability-to-wait have been attributed to self-control, in part because of evidence that long-delayers are more successful in later life (e.g., Shoda, Mischel, & Peake, 1990). Here we provide evidence that, in addition to self-control, children's wait-times are modulated by an implicit, rational decision-making process that considers environmental reliability. We tested children ($M = 4;6$, $N = 28$) using a classic paradigm—the marshmallow task (Mischel, 1974)—in an environment demonstrated to be either *unreliable* or *reliable*. Children in the *reliable* condition waited significantly longer than those in the *unreliable* condition ($p < 0.0005$), suggesting that children's wait-times reflected reasoned beliefs about whether waiting would ultimately pay off. Thus, wait-times on sustained delay-of-gratification tasks (e.g., the marshmallow task) may not only reflect differences in self-control abilities, but also beliefs about the stability of the world.

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1. Introduction

When children draw on walls, reject daily baths, or leave the house wearing no pants and a tutu, caretakers may reasonably doubt their capacity for rational decision-making. However, recent evidence suggests that even very young children possess sophisticated decision-making capabilities for reasoning about physical causality (e.g., Gopnik et al., 2004; Gweon & Schulz, 2011), social behavior (e.g., Gergely, Bekkering, & Király, 2002), future events (e.g., Denison & Xu, 2010; Kidd, Piantadosi, & Aslin, 2012; Téglás et al., 2011), concepts and categories (e.g., Piantadosi, Tenenbaum, & Goodman, 2012; Xu, Dewar, & Perfors, 2009), and word meanings (e.g., Xu & Tenenbaum, 2007). Here we demonstrate that young children also use their rational decision-making abilities in a domain of behavioral inhibition: a sustained delay-of-gratification task.

Decision-making is said to be rational if it maximizes benefit or utility (Anderson, 1991; Anderson & Milson, 1989; Marr, 1982), yet young children's decisions during delay-of-gratification tasks often appear to do just the opposite (e.g., Mischel & Ebbesen, 1970). When asked to resist the temptation of an immediately available low-value reward to obtain one of high-value after a temporal delay, 75% of children failed to do so, succumbing to their desire after an average of 5.72 min. The cause of these apparent failures of rationality, however, is not fully understood. While children's failures to wait are likely the result of a combination of many genetic and environmental variables, two potentially important factors are *self-control capacity* and *established beliefs.*

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1.1. Deficient capacity hypothesis

One possible explanation for failing to wait for a larger reward is a deficiency in *self-control*; some children are simply incapable of inhibiting their immediate-response tendency to seek gratification. Young infants, for example, have not yet developed the executive functions necessary for inhibitory control (e.g., Piaget, 1970), as evidenced by the perseveration errors made by up to 2-year-old children in A-Not-B tasks (e.g., Marcovitch & Zelazo, 1999; Piaget, 1954). As predicted by this theory, children's ability to delay gratification improves with maturation (e.g., Mischel & Metzner, 1962). Maturational changes, however, are insufficient to account for all of the variance in task performance (e.g., Romer, Duckworth, Sznitzman, & Park, 2010). *Individual differences* in children's capacities for self-control may account for the remaining variance.

Self-control has been implicated as a major causal factor in a child's later life successes (or failures). Mischel, Shoda, and Peake (1988) analyzed data from adolescents who, many years earlier, had been presented with a laboratory choice-task: eat a single marshmallow immediately, or resist the temptation during a sustained delay to receive two marshmallows. With no means of distracting themselves from a treat left in view, the majority of children failed to wait for the maximum delay (15 or 20 min) before eating the marshmallow, with a mean wait-time of 6 min and 5 s. Importantly, longer wait-times among children were correlated with greater self-confidence and better interpersonal skills, according to parental report. Longer wait-times also correlated with higher SAT scores (Shoda et al., 1990), less likelihood of substance abuse (Ayduk et al., 2000), and many other positive life outcomes (e.g., Mischel, Shoda, & Rodriguez, 1989). Based on these findings, the marshmallow task was argued to be a powerful diagnostic tool for predicting personal well-being and later-life achievement—"an early indicator of an apparently long-term personal quality" (Mischel et al., 1988). The logic of the claim is that a child who possesses more self-control can resist fleeting temptations to pursue difficult goals; in contrast, children with less self-control fail to persist toward these goals and thus achieve less. To be clear, the evidence for poor self-control in young children (e.g., Baumeister, Heatherton, & Tice, 1994; Goleman, 1995), in a wide variety of tasks and contexts, is undeniable. At issue is the *origin of failure* of delay-of-gratification in laboratory tests like the marshmallow task, which has remained largely speculative (Mischel et al., 1989, p. 936).

1.2. Rational decision-making hypothesis

Another possibility is that the variance in children's performance may be due to differences in children's expectations and beliefs (Mahrer, 1956; Mischel, 1961; Mischel & Staub, 1965). Under this theory, children engage in rational decision-making about whether to wait for the second marshmallow. This implicit process of making rational decisions is based upon beliefs that the child acquired before entering the testing room. The basis for this theory centers on what it means to be rational *in the context* of the marshmallow task. Waiting is only the rational choice if you believe that a second marshmallow is likely to actually appear after a reasonably short delay—and that the marshmallow currently in your possession is not at risk of being taken away. This presumption may not apply equally to all children. Consider the mindset of a 4-year-old living in a crowded shelter, surrounded by older children with little adult supervision. For a child accustomed to stolen possessions and broken promises, the only guaranteed treats are the ones you have already swallowed. At the other extreme, consider the mindset of an only-child in a stable home whose parents reliably promise and deliver small motivational treats for good behavior. From this child's perspective, the rare injustice of a stolen object or broken promise may be so startlingly unfamiliar that it prompts an outburst of tears. The critical point of the foregoing vignette is that rational behavior is inferred by understanding the goals and expectations of the agent (Anderson, 1991; Anderson & Milson, 1989; Marr, 1982). Relevant to this hypothesis is the fact that children with absent fathers more often prefer immediate, lesser rewards over delayed, more valuable ones (Mischel, 1961). Also, children's willingness to wait is negatively impacted by uncertainty about the likelihood, value, or temporal availability of the future reward (Fawcett, McNamara, & Houston, 2012; Mahrer, 1956; McGuire & Kable, 2012; Mischel, 1974; Lowenstein, Read, & Baumeister, 2003). These effects are consistent with the idea that children may be capable of engaging in a rational process when deciding whether or not to wait.

In support of this second hypothesis, we present evidence that the reliability of the experimenter in the testing environment influences children's wait-times during the marshmallow task. Half of the children observed evidence that the researcher was *reliable* in advance of the marshmallow task, while half observed evidence that she was *unreliable*. If children employ a rational process in deciding whether or not to eat the first marshmallow, we expect children in the reliable condition to be significantly more likely to wait than those in the unreliable condition. Our experiment provides a fundamental test of this perspective on children's rational behavior and provides compelling evidence that young children are indeed capable of delaying gratification in the face of temptation when provided with evidence that waiting will pay off.

2. Materials and methods

2.1. Participants

Twenty-eight caretakers volunteered their children (ages 3;6 – 5;10) for the study. The children were all healthy, had not recently visited the lab (within 2 months), and had not interacted with researchers running the study since infancy. These precautions ensured children had minimal prior expectations specific to the lab or researcher's reliability before this study. Children were randomly assigned to one of two experimental conditions—*unreliable* and *reliable*—such that each group was gender and age balanced (nine males, five females, and $M = 4;6$). Participants received a small treat bag and $10 as compensation.

2.2. Procedure

2.2.1. Art project task

Before the marshmallow task, children were first provided with evidence about the reliability of the researcher through the completion of a two-part art project involving a Create-Your-Own-Cup kit (with which children could decorate a blank paper slip to be inserted into a special cup). Each of the project's two parts involved a crucial choice. In Choice 1, the child could either use well-used crayons or wait for a new set of art supplies. In Choice 2, the child could either use one small sticker or wait for a new set of better stickers. Upon arrival, children were escorted to the ''art project room'' that was not part of the normal lab space and where parents could covertly observe them from the main lab space.

For Choice 1, the researcher presented the child with a small set of well-used crayons in a tightly sealed wide-mouth jar. The researcher explained that the child could use the crayons now, or wait until the researcher returned with a brand-new set of exciting art supplies to use instead. The researcher then placed the tightly sealed crayon jar in the center of the table and left the child alone in the room to wait for 2.5 min. Though we wanted children to ostensibly have a choice, we wanted them to choose to wait. Thus, the chosen container was intentionally difficult to open. This manipulation was successful, and all children waited the full 2.5 min without using the well-used crayons. In the *unreliable* condition, the researcher returned without the promised art set and provided the following explanation: ''*I'm sorry, but I made a mistake. We don't have any other art supplies after all. But why don't you just use these instead?*'' The researcher then helped the child open the jar of well-used crayons. In the *reliable* condition, the researcher returned with a rotating tray featuring a large assortment of exciting art supplies. (See Appendix A.1 for full scripted dialog.) In both conditions, the researcher encouraged the child to draw for 2 min.

For Choice 2, the researcher produced a round 1/4-in. reward-style sticker from their pocket sealed inside of a plastic envelope. The researcher explained that they could use the small sticker now, or wait until the researcher returned with a larger number of better stickers to use instead. The researcher then placed the small sealed sticker in the center of the table and left the child alone in the room to wait for 2.5 min. As in Choice 1, the sticker packaging was also difficult-to-open by design: the sticker was glued down and covertly sealed inside the plastic envelope with superglue. This preparation was ultimately unnecessary, however, as children were so occupied with drawing during this delay that they did not examine the sticker. This manipulation was also successful, and all children waited the full 2.5 min. without using the 1/4-in. reward-style sticker. In the *unreliable* condition, the researcher returned without the promised stickers and provided the following explanation: ''*I'm sorry, but I made a mistake. We don't have any other stickers after all. But why don't you just use this one instead?*'' The researcher then offered assistance to the child in opening the sealed sticker package, and then covertly swapped it out for an identical usable version. In the *reliable* condition, the researcher returned with 5–7 large die-cut stickers featuring a desirable theme (e.g., Toy Story, Disney Princesses). Unbeknownst to the child, the caretaker selected that set of stickers to be especially desirable in advance of the study. In both conditions, the researcher then encouraged the child to work on their drawing for 2 min.

Thus, children were provided with two sources of evidence that the experimenter—and more generally the testing situation—was either *unreliable* or *reliable*.

2.2.2. Marshmallow task

The marshmallow task immediately followed the two-part art task. Once the table was cleared, the researcher revealed a single marshmallow to the child and provided the following explanation:

> ''*You finished just in time, because now it's snack time! You have a choice for your snack. You can eat this one marshmallow right now. Or—if you can wait for me to go get more marshmallows from the other room—you can have two marshmallows to eat instead. How does that sound? [Response.] Okay, I'm going to go get more marshmallows from the other room and turn your picture into a cup! You should stay right here in that chair. Can you do that? [Response.] I'll leave this [marshmallow] here, and if you haven't eaten it when I come back, you can have two marshmallows instead!*''

The researcher placed the marshmallow directly in front of the child, 4 in. from the table's edge. The researcher then quickly collected the art materials and drawing and exited the room. The child was left alone in the room, while under covert observation via webcam, until either they consumed the marshmallow or until 15 min had elapsed. Regardless of whether they waited, each child was ultimately given three additional marshmallows at the conclusion of the study.

We note that this final portion of the experimental procedure is slightly different from those used by the studies analyzed in Shoda et al. (1990). Major features of the delay situation are identical; however we did not require children to explicitly signal their desire to stop waiting before eating the lesser treat. The original paradigms involved training children to expect that the experimenter would return upon use of an explicit signal (e.g., ringing a bell). Since this would necessarily provide children with additional information about the experimenter's reliability (as well as add time and complication to our already lengthy experimental procedure), we omitted it. As an additional benefit, this simplified procedure ensures that even very young children could quickly and easily understand the task.

2.2.3. Coding

Two naïve coders (who were unaware of the experimental conditions) reviewed blinded videos of children in the marshmallow task and recorded when each child's first taste—a lick or bite—occurred. Judgments were checked against one another to ensure reliability: 78.57% matched exactly, 14.29% differed by 1 s, and 7.14% differed by 2 s. When judgments differed, the later time was used. Coders also quantified excitement by measuring smiling time (s) and assigning a subjective rating of apparent contentedness (on 1–9 scale) at the onset of the waiting period (first 30 s). Additionally, the degree of physical movement (fidgetiness) was measured via a computer script that quantified the mean number of pixel changes across frames during the same 30-s time interval.

3. Results

Mean wait-times are shown in Fig. 1. Because the task was terminated at 15 min, children who had not eaten the marshmallow may have waited longer if the experimental design had permitted. Thus, this analysis is a conservative estimate of the true difference between the two conditions. Children in the *unreliable* condition waited without eating the marshmallow for a mean duration of 3 min and 2 s ($M = 181.57$ s). In contrast, children in the *reliable* condition waited 12 min and 2 s ($M = 722.43$ s). A Wilcoxon rank-sum test (also known as a *Mann–Whitney Wilcoxon* or a *Mann–Whitney U*) confirmed that this difference was highly significant ($W = 22.5$, $p < 0.0005$). Thus, children in the *unreliable* condition waited significantly less than those in the *reliable* condition.

We also conducted a binary analysis of whether children waited the entire 15 min without tasting the marshmallow (Fig. 2). In the *unreliable* condition, only 1 out of the 14 children (7.1%) waited the full 15 min; in the *reliable* condition, however, 9 out of the 14 children (64.3%) waited. A two-sample test for equality of proportions with continuity correction at $\alpha_{2\text{-}tail} = 0.05$ (Newcombe, 1998) was highly significant ($X^2 = 7.62$, $df = 1$, $p < 0.006$). Thus, children in the *unreliable* condition were significantly less likely to wait the full 15 min than those in the *reliable* condition.

Additionally, we performed a linear regression with age and gender as predictors, controlling for condition. Neither factor—age ($\beta = 8.57$, $t = 1.29$, $p > 0.20$) nor gender ($\beta = -11.63$, $t = -0.10$, $p > 0.92$)—was significant in our sample. Detailed subject data appear in Appendix A.2.

Since these results might alternatively be explained by a difference in mood across the two groups (e.g., by differently induced levels of either frustration or excitement), an analysis of the three relevant measures—apparent contentedness, smiling, and fidgetiness—was conducted (see Appendix A.3). Results suggested that these variables did not vary systematically across the two conditions.

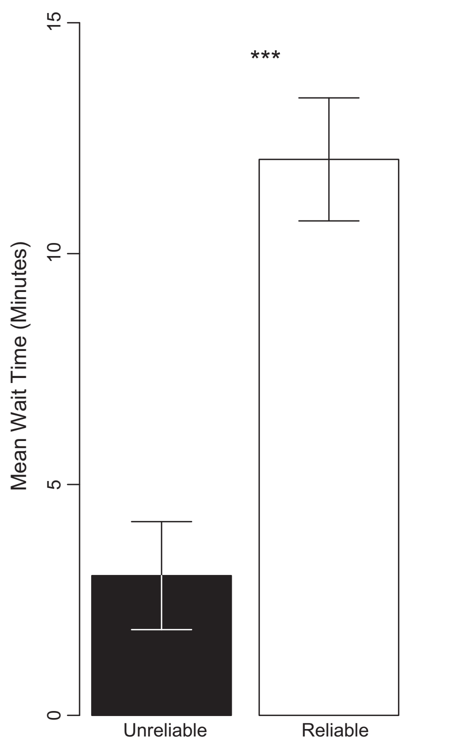

Fig. 1. Mean wait-times of children in each condition. Error bars show 95% confidence intervals. Children in the unreliable condition waited without eating the marshmallow for a mean duration of 3 min and 2 s ($M = 181.57$ s). In contrast, those in the reliable condition waited 12 min and 2 s ($M = 722.43$ s). A Wilcoxon signed-rank test found this difference to be highly significant ($W = 22.5$, $p < 0.0005$). Here, 15 min was used as the wait-time for children who did not eat the marshmallow until the researcher returned, though these children may have actually waited longer if the experimental design had permitted.

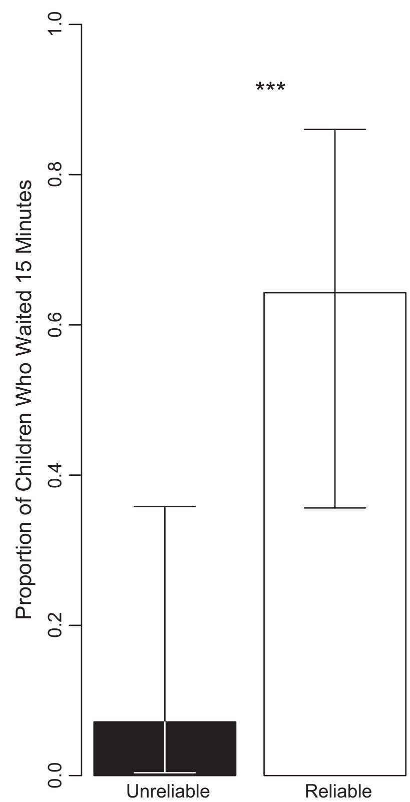

Fig. 2. Proportion of children who waited the full 15 min without eating the marshmallow by condition. Error bars show 95% confidence intervals. In the unreliable condition, only 1 out of the 14 children (7.1%) waited the full 15 min; in the reliable condition, however, 9 out of the 14 children (64.3%) waited. We tested the difference using a two-sample test for equality of proportions with continuity correction at $\alpha_{2\text{-}tail} = 0.05$. The test found it to be highly significant ($X^2 = 7.6222$, $df = 1$, $p < 0.006$).

4. Discussion

The results of our study indicate that young children's performance on sustained delay-of-gratification tasks can be strongly influenced by rational decision-making processes. If self-control capacity differences were the primary causal mechanism implicated in children's wait-times, then information about the reliability of the environment should not have affected them. If deficiencies in self-control caused children to eat treats early, then one would expect such deficiencies to be present in the *reliable* condition as well as in the *unreliable* condition. The effect we observed is consistent with converging evidence that young children are sensitive to uncertainty about future rewards (Fawcett et al., 2012; Mahrer, 1956; McGuire & Kable, 2012).

The resulting effect of our experimental manipulation was quite robust (ΔM_{delay} = 9 min, $p < 0.0005$). Importantly, while there were small procedural differences between our study and past studies, children—age and gender-matched to the current study—who faced similar choices *without prior explicit evidence of experimenter reliability* waited for around 6 min (e.g., 6.08 min in Shoda et al. (1990)[1] and 5.71 min in Mischel & Ebbesen (1970)[2]). When we manipulated experimenter reliability, children waited twice that long in the *reliable* condition (12.03 min), and half as long in the *unreliable* condition (3.02 min). While further work will be required to explicitly test the relative contributions of different factors, preliminary comparisons suggest that the influence of a child's beliefs about the reliability of the world is at least comparable to their capacity for self-control.[3]

To be clear, our data do not demonstrate that self-control is irrelevant in explaining the variance in children's wait-times on the original marshmallow task studies. They do, however, strongly indicate that it is premature to conclude that most of the observed variance—and the longitudinal correlation between wait-times and later life outcomes—is due to differences in individuals' self-control capacities. Rather, an unreliable worldview, in addition to self-control, may be causally related to later life outcomes, as already suggested by an existing body of evidence (e.g., Barnes & Farrell, 1992; Smyke, Dumitrescu, & Zeanah, 2002).

5. Conclusions

We demonstrated that children's sustained decisions to wait for a greater reward rather than quickly taking a lesser reward are strongly influenced by the reliability of the environment (in this case, the reliability of the researcher's verbal assurances). More broadly, we have shown that young children's performance on delay-of-gratification tasks can be strongly influenced by an implicit rational decision-making process.

[1] Condition: exposed reward, no ideation instructions.

[2] Condition: immediate reward.

[3] Two additional manipulation results from Shoda et al. (1990) that may inform relative effect-size estimates: (1) obscuring visual contact with the rewards during the wait (*attention manipulation*) increased mean wait-times by 3.75 min and (2) suggesting that children think about the larger reward (*ideation strategy*) increased them by 2.53 min.

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Appendix A. Supplementary material

Supplementary material associated with this article includes additional scripted dialogue (A.1), detailed subject data (A.2), and the analysis of mood variables (A.3). This material is part of the online version at http://dx.doi.org/10.1016/j.cognition.2012.08.004.

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Appendix A. Supplementary material

A.1. Additional scripted dialogue

The experimenter used the following scripted dialog to explain each stage of the testing procedure to young study participants.

1. **Onset of experiment** – *"So, today we have a very exciting art project planned for you! Upstairs, we have everything we'll need for you to make your own cup like this one! And you'll be able to take it home with you! Does that sound like something you'd like to do?"*

2. **Art material choice** – "*To decorate your cup, you have a choice of what art supplies to use. You could use these [crayons] right now. Or—if you can wait for me to go get them from another room—you can use our big set of art supplies instead. The big set has markers, pens, colored pencils—a lot of cool stuff. How does that sound? [Response.] Okay, I'm going to go get the big set of art supplies from the other room. You should stay right here in that chair. Can you do that? [Response.] I'll leave these [crayons] right here, and if you haven't used them when I come back, you can use our big set of art supplies instead!"*

3. **Sticker choice** – *"Would you like to add a sticker to your picture? [Response.] For stickers, you have a choice. You can use this [sticker] right now. Or—if you can wait for me to go get them from the other room—you can have a bunch of stickers to use instead. How does that sound? [Response.] Okay, I'm going to go get more stickers from the other room. You should stay right here in that chair. Can you do that? [Response.] I'll leave this [sticker] here and if you haven't used it when I come back, you can have a bunch of stickers to use instead!"*

A.2. Detailed subject data

Table A.1 contains the wait-time judgments of two video coders for each child participating in the study. Children were randomly assigned to one of two experimental conditions—unreliable and reliable—such that each group was gender and age balanced (nine males, five females, and *M* = 4;6). Two naïve coders watched videos of the children waiting during the final stage of the testing procedure (the marshmallow task). The videos were blinded for condition. The coders measured each child's wait-time until first taste (i.e., lick or bite). The coders' timing judgments were checked against one another to ensure validity, and when timing judgments differed, the later judgment was used (and appears in bold in Table A.1). The judgments of the

Table A.1. Gender, age, and wait-times for each study participant.

Condition	Subject ID	Gender	Age	*Wait-time (s)* Coder 1	Coder 2	Diff	Waited 15
	1	m	3;7	17	17	*0*	n
	3	f	4;0	**21**	19	*2*	n
	5	m	4;0	7	7	*0*	n
	7	m	4;0	15	15	*0*	n
	9	f	4;0	10	10	*0*	n
	11	f	4;1	31	31	*0*	n
Unreliable	13	m	4;4	496	**498**	*-2*	n
	15	f	4;5	900	900	*0*	**y**
	17	m	4;6	457	457	*0*	n
	19	m	4;10	72	**73**	*-1*	n
	21	m	5;3	18	18	*0*	n
	23	m	5;4	150	150	*0*	n
	25	f	5;7	195	195	*0*	n
	27	m	5;7	149	**150**	*-1*	n
		9m, 5f	***M = 4;6***	***M = 181.57***			***7.14%***
	2	m	3;7	900	900	*0*	**y**
	4	m	3;8	785	785	*0*	n
	6	f	3;8	**431**	430	*1*	n
	8	f	4;0	900	900	*0*	**y**
	10	m	4;0	59	59	*0*	n
	12	f	4;1	144	**145**	*-1*	n
Reliable	14	m	4;6	900	900	*0*	**y**
	16	f	4;6	900	900	*0*	**y**
	18	m	4;7	900	900	*0*	**y**
	20	m	4;9	900	900	*0*	**y**
	22	m	4;11	594	594	*0*	n
	24	f	5;5	900	900	*0*	**y**
	26	m	5;9	900	900	*0*	**y**
	28	m	5;10	900	900	*0*	**y**
		9m, 5f	***M = 4;6***	***M = 722.43***			***64.29%***

Table A.2. Mood-variable means and statistical significance tests.

	Group means			
	Unreliable (N = 14)	**Reliable** (N = 14)	**Wilcoxon rank sum test**	**Independent samples t-test**
Contentedness *(z-scores)*	$M = 0.03$ *(sd = 0.89)*	$M = -0.03$ *(sd = 0.89)*	$W = 106.5, p > 0.71$	$t = 0.178, df = 26, p > 0.85$
Smiling *(s)*	$M = 3.16$ *(sd = 3.68)*	$M = 4.45$ *(sd = 6.53)*	$W = 96.5, p > 0.96$	$t = 0.644, df = 26, p > 0.52$
Fidgeting *(interframe pixel change)*	$M = 0.61$ *(sd = 0.36)*	$M = 0.61$ *(sd = 0.39)*	$W = 97, p > 0.98$	$t = 0.000, df = 26, p = 1.00$

two coders were found to differ by at most 2 s on each wait-time. Children's behavior was also coded in terms of a binary outcome measure corresponding to whether or not they waited the entire 15 min without tasting the marshmallow (as indicated in the "Waited 15" column in Table A.1). The percentages in this column reflect the portion of the group that waited the full 15 min: 7.14% in the *unreliable* condition and 64.29% in the *reliable* one.

A.3. Analysis of mood variables

We used three control variables to investigate the potential influence of mood on children's wait times: *contentedness*, *smiling*, and *fidgeting*. Each measurement was based on a portion of each child's video data—the first 30 s of the waiting period.

1. **Contentedness** – Two naïve coders rated each child's apparent contentedness on a scale from 1-9, with 1 indicating *very sad* and 9 indicating *very happy*. We computed z-scores for each coder's judgments, and then a mean z-score for each child.
2. **Smiling** – Two naïve coders measured for how long each child smiled (s). We use the mean of these two judgments.
3. **Fidgeting** – A Python script automatically calculated an estimate of each child's movement. The script computed the mean number of pixel changes frame-to-frame for each child, above a noise threshold (diff > 50). The threshold served to control for pixel changes caused by the noise inherent in digital frame-to-frame comparisons of this type (caused by, for example, small differences in compression and subtle lighting changes). Thus, the threshold enabled us to measure only changes caused by the body movements of each child.

The mood-variable means for each group and the results of two types of statistical tests appear in **Table A.2**. Wilcoxon rank sum tests indicated that these variables did not significantly differ across conditions in our sample population. Independent samples t-tests ($\alpha_{2\text{-}tail} = 0.05$) also failed to detect significant differences across conditions.