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Sign effect in adolescents: Within-subject comparison of delay discounting of hypothetical monetary gains and losses

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The purpose of this article is to contribute to the research on the sign effect, steeper discounting of gains compared to losses, by offering results from an experiment using a "double-delay" procedure on adolescents. Twenty-four 14-year-old schoolchildren completed a computer-based test consisting of choices of Smaller–Sooner (SS) and Larger–Later (LL) hypothetical monetary gains and losses. Within-subject comparison and analysis of the aggregated data were conducted. Current results were also examined in light of prior research with adult participants, and variations in behavioral patterns were identified. Although the sign effect appears to be more profound in adolescents compared to adults, the effect of immediacy persists regardless of the sign of the outcome, and zero discounting of losses is often the case, suggesting that the sign effect is driven largely by qualitative differences.

Key words: sign effect, discounting, gains, losses, immediacy, adolescents

Delay discounting is defined as the tendency people have to systematically devalue outcomes, positive or negative, the further into the future they appear (Madden & Bickel, 2010). Individual discount functions are often hyperbolic; the functions have declining discounting rates over time (Ainslie & Haslam, 1992; Mazur, 1987). This implies a stronger emphasis on the proximate outcome, but also the relative emphasis on alternative outcomes. The Smaller–Sooner outcome (SS) is discounted significantly less than the Larger–Later outcome (LL) when these alternatives are relatively near, whereas the discounting rates of the same alternatives approximate each other as they become more distant. Discounting is indicated by a decline in the Indifference Point (IP) as the delay increases. Indifference point is the point where the subject changes between preferring one or the other alternative (Madden & Bickel, 2010).

Studies have shown that although discounting of positive and negative outcomes results in the same hyperbolic shape, positive outcomes are discounted more steeply than negative outcomes (Abdellaoui et al., 2010; Estle et al., 2006; Frederick et al., 2002; Mitchell & Wilson, 2010). This difference is referred to as the sign effect. The subjective value of a loss decreases at a lower rate than the subjective value of a gain as delay increases. Discounting studies using hypothetical monetary outcomes on adult participants, typically show a clear sign effect (e.g., Estle et al., 2006; Frederick et al., 2002; Gonçalves & Silva, 2015; Thaler, 1981). On an individual level the sign effect appears to result from quantitative as well as qualitative differences (Myerson et al., 2017). Quantitative differences here refer to the steepness of the discounting function or the degree of devaluation. Qualitative differences, on the other hand, are differences in the shape or pattern of the discounting function that contradict the systematic devaluation of hyperbolic discounting.

Discounting is found to change with age. In one study where participants had the choice between immediate and delayed hypothetical monetary rewards, choice behavior was compared between children, young adults and older adults (Green et al., 1994). This research demonstrated steepest discounting among children, less among young adults, and even less discounting among the older adults. The younger participants discounted the value of the delayed reward at a higher rate than older participants. A later study compared the results of Green et al. (1994) with new data (Green et al., 1999) and again found a change in steepness, but also a change in the *shape* of the discount function, although a hyperbola-like function provided a good description of

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the discounting behavior at all ages. For some individuals the subjective value of the reward had a stronger negative acceleration than predicted by the simple hyperbola. Funder and Block (1989) used monetary rewards in their experiment and recruited 14-year-olds to take part in a test consisting of six parts. They could choose between receiving their payment after completing each part or postpone one or several of the payments until all the parts were through in which they would earn interest and hence earn more altogether. Eighty-three out of 104 subjects managed to delay gratification the maximum amount of times, that is, postpone payment in all possible sessions. These results displayed a pattern of choices between gains similar to what is seen among adults. Scheres et al. (2006) examined temporal discounting of real rewards and real delays between two age groups, children (6-11) and adolescents (12-17), and found that the discounting curves for children were steeper than for adolescents. There were two conditions. One condition included a postreward delay; thus, the trial length would be the same regardless of whether the immediate or delayed reward was chosen. In the second condition, without a postreward delay, the overall trial length would be shorter if the immediate outcome was chosen. The lack of difference in results between conditions, they argue, indicated that the choices in this experiment were driven mainly by the immediacy of the reward rather than avoidance of delay.

There are also findings that contradict the systematic devaluation paradigm, which is the foundation of the sign effect. Although the subjective perception of value typically decreases as delay to a *reward* increases (Estle et al., 2007; Hantula & Bryant, 2005), the perceived subjective value, or the aversion, of a *negative outcome* does not always systematically change as the delay to it increases. Early results from studies with adult participants indicated that people prefer to delay aversive outcomes such as small monetary losses (Yates & Watts, 1975). Other studies reported that although the subjective value of a small monetary gain, or an item like gum or a notepad, would decrease, the subjective value of a monetary loss, unpleasant food or annoying sounds, would not decrease as delay increased (Mischel et al., 1969). Neither adults nor children demonstrated significant loss discounting in this study. The adult participants consistently chose the immediate punishment over delayed punishment. The choices by the children were not systematically affected by delay in any way, in the case of losses. Recent studies have also shown that the willingness to wait for a gain was different between adolescents with and without ADHD, but the willingness to wait for a (smaller) loss was not different between the groups (Mies et al., 2019). Further, studies report that while some adult participants discount losses similar to how they discount gains, others may show "negative" discounting (Hardesty et al., 2013), increasingly/decreasingly preferring sooner rather than later losses, or "zero" discounting of losses (Furrebøe, 2020), choosing the sooner loss regardless of delay. These results are consistent with other studies demonstrating qualitative differences between discounting of gains and losses. Myerson et al. (2017) investigated choices between hypothetical monetary gains and losses; immediate gains versus larger delayed gains, and immediate losses versus larger delayed losses. They found that discounting of gains typically differs quantitatively between adult humans, while discounting of losses also differ qualitatively, displaying unsystematic discounting shapes. On an individual level these qualitative differences appeared to result from three different behavioral subgroups: 1) Minimizers, unaffected by magnitude consistently choosing the smaller loss (zero discounting), 2) Debt averse, experiencing the loss more averse the more delayed it is (reverse discounting), and 3) Loss averse, choosing based on magnitude (discounting).

A majority of discounting studies, regardless of sign of the outcome, use a titration procedure involving a smaller immediate outcome (SS) and a larger delayed outcome (LL) with a varying delay to the LL and the value of one or both of the outcomes (Estle et al., 2006; Friedel et al., 2016; Gonçalves & Silva, 2015). This type of procedure emphasizes the importance of how responses are driven by the immediacy of an outcome. By using conditions with and without a postreward delay in a real reward study, Scheres et al. (2006) demonstrated that the steeper discounting among children compared to adolescents was driven mainly by reward immediacy. This finding is important because it distinguishes between the effect of immediacy to the outcome and

the effect of delay aversion. The hyperbolic discount function with its declining discounting rates over time involves the immediacy of each outcome, but also implies considerations about the relative values between delayed outcomes as they change (Ainslie & Haslam, 1992; Mazur, 1987; Prelec & Loewenstein, 1991). A procedure where both outcomes are delayed and adjusted, emphasizes these relative values, yet recognizes the effect of immediacy. Only a few discounting studies have used a procedure with two delayed gains (Green et al., 2005; Kable & Glimcher, 2010; Mitchell & Wilson, 2010), two delayed losses (Holt et al., 2008), or two delayed gains and losses (Furrebøe, 2020). Green et al. (2005) were the first to show that discounting obtained when choices involve two delayed rewards can also be described by the hyperbolic function. Similarly, Kable and Glimcher (2010) examined discounting of two delayed rewards and found that the value of LL declined hyperbolically at a similar rate as when the SS was immediate. They argued that humans encode subjective value of rewards at any delays, and not necessarily reach preference reversal as predicted by hyperbolic discounting. Mitchell and Wilson (2010) compared smokers' and nonsmokers' discounting in both a SmallNow versus LargerLater and a SmallSoon versus LargerLater procedure, and found that discounting occurred also in the "double-delay" procedure albeit to a lesser degree, underlining that the difference in discounting is not *solely* due to the response to the immediate outcome.

More knowledge is needed about how and why the discounting patterns for gains and losses differ. Studies examining whether the qualitative and quantitative differences previously found in discounting of gains and losses (Myerson et al., 2017), using a "double-delay" procedure is called for. Specifically, it remains to be seen if such a procedure conducted on adolescents will yield similar discounting patterns as for adults (Furrebøe, 2020). If the sign effect, in fact, is a display of different competing contingencies involving the effects of immediacy of the outcomes as well as considerations of relative values of delayed outcomes, we expect at least as large a sign effect on an aggregate level, and equally large qualitative variations on an individual level, to appear in adolescents as we have seen in adults.

Method

Participants

Given the results from earlier studies with adolescents (Funder & Block, 1989; Scheres et al., 2006), we considered the age of 14-15 to be an appropriate age of the participants of this study, and in order to efficiently recruit participants in this age group and of both sexes, we contacted a local school. Twenty-four pupils (10 girls and 14 boys) from grade 9, all between 14 and 15 years of age, participated in the study. Their parents gave a written assent before they took part in the test. Each participant had an appointed time during school hours in which they completed the task on a portable PC in a separate classroom at their school with one researcher present. In addition to the written information received 3 weeks before the test, each participant got the same information orally when arriving to the test in the classroom, to make sure they had understood what the task involved. There were also onscreen information and reminders as they proceeded through the task. The participants received information about the anonymity of the data, and about their right to withdraw at any time.

Procedure

In order to be able to obtain a discounting pattern, we used a choice-based technique consisting of binary comparisons between Smaller–Sooner (SS) and Larger–Later (LL) hypothetical alternatives. The current procedure was based on a previously used "double-delay" procedure (Holt et al., 2008), and adjusted to fit discounting tasks for both gains and losses (Furrebøe, 2020).

As each trial appeared on screen, the participants indicated their preference by responding to one out of two corresponding keys. The participants went through two sequences: one sequence (gain scenario) with choices between *receiving* a smaller hypothetical amount of money sooner or a larger hypothetical amount of money later; the other (loss scenario) with choices between *paying* a smaller hypothetical amount of money sooner or a larger hypothetical amount of money

later. The smaller–sooner amount, regardless of the amount to be paid or received, was 3000 Norwegian Kroner (NOK), approximately $380 USD, and the larger–later amount was 4500 NOK, approximately $550 USD. To control for order effects the sequence order was counterbalanced across participants by assigning every other participant to either of the Gain–Loss or Loss–Gain condition upon arriving to the test room.

There were seven sequences of varying delay difference (1 month, 3 months, 1 year, 3 years, 7 years, 10 years, and 20 years) and 15 SS delays (1 week, 2 weeks, 1 month, 3 months, 6 months, 1 year, 2 years, 3 years, 5 years, 7 years, 10 years, 12 years, 15 years, 17 years, and 20 years). Delay difference is the time difference between the delivery of the SS and LL outcome. SS delay is the delay before the delivery of the SS outcome. The chosen time intervals were based on previous research on adult participants (Furrebøe, 2020). The number of delay-difference trials were, however, reduced from 11 to 7, in order to limit the test to last no more than 30 min. Both scenarios started by increasing delay difference. The sole purpose was to have a control/reference point for the first IP obtained later during the SS delay adjustment. It had no consequence for the continuation of the discounting task. The control/reference point is the point where the participants changed (if they changed) from choosing LL gain (or SS loss in the loss scenario) to SS gain (or LL loss in the loss scenario) during the initial delay-difference increase (Table 1). Notably, those who reached 20 years in fact never changed preference during this increase. Afterwards the delay-difference remained constant as SS delay was adjusted. All participants, regardless of control/reference point, completed SS delay adjustments through all seven delay-difference sequences in the same order from 1 month to 20 years. First, SS delay increased until the participant chose LL gain/SS loss, or until they reached maximum SS delay of 20 years. Next, the SS delay decreased from 20 years until preference changed back, or until the participant had proceeded through all the SS delays in that specific delay-difference sequence. This up and down adjustment repeated for all seven delay-difference sequences. The total number of possible choice trials were 210 (2 x 7 x 15). However, preference typically changed before all SS delay conditions were presented, up or down, in each delay-difference sequence. Appendix I illustrates a selection of adjustment sequences (the initial delay-difference increase + SS delay adjustments for 3 months delay-difference + SS delay adjustment for 1 year delay difference), as well as the corresponding choice patterns made by Participant 110 during the gain scenario.

Table 1

Control/Reference Points from the Delay-Difference Increase Sequence

	Scenario	
Participant	Gain	Loss
99	1 year	20 years
100	1 month	7 years
101	3 years	1 month
102	1 year	10 years
103	1 year	1 year
104	7 years	1 month
105	1 year	20 years
106	3 years	20 years
107	3 months	7 years
108	7 years	20 years
109	1 year	20 years
110	3 years	20 years
111	1 year	3 years
112	1 year	1 month
113	1 year	20 years
114	1 month	20 years
115	3 years	7 years
116	10 years	20 years
117	1 month	20 years
118	3 years	20 years
119	1 year	10 years
120	1 year	20 years
121	1 year	20 years
122	1 year	20 years

We obtained seven indifference points (IP), points where the participants changed (if they changed) between their tendency of responding to SS or LL during each of the seven delay-difference trials. From these seven points, we plotted discounting curves for both the gain scenario and the loss scenario for each participant taking part in the experiment, and the area under the curve (AUC; Myerson et al., 2001) was calculated and compared between gains and losses on an aggregate level.

The participants completed a brief training session similar to the test prior to the actual test. It lasted for approximately 10 min. After the test, the participant registered his/her age

and gender. In addition to the actual test consisting of hypothetical questions, all the participants could choose between a glass of soda (2 dl.) while doing the test, or to take home a bottle (5 dl.) of the same soda at the end of the day. The purpose was to have a real time, real reward setting in addition to the hypothetical test, and to compare the hypothetical and real results on an individual level. The same researcher provided the information, administered the training session, as well as the test for all participants.

Results

Table 2 shows the individual AUC_{gain} and AUC_{loss} for each of participants in the experiment. Of the 24 participants, 22 discounted gains more than losses. Two participants (Participant 100 and 112) discounted losses more than or similar to gains. The mean $AUC_{gain} = 0.22$ and $AUC_{loss} = 0.87$.

Figure 1 is the graphical representation of the mean IP values and the mean AUC of gains and losses. In the first panel are the mean values of the seven obtained IPs, the x-axis shows the delay-difference in years, the y-axis the discounted value measured in SS delay at IP (1000 weeks – IP), that is, how delayed are the outcomes before one shifts from choosing LL gain to SS gain or from choosing SS loss to LL loss. The graph depicts a steep curve of gains discounting, and a flatter curve for loss discounting. In fact, the curve for losses depicts no overall discounting, since the curve first decreases and then increases again to the same level. In the second panel of the same figure we see the bar chart of the means AUC by sign: Mean $AUC_{gain} = 0.22$, SD = 0.20, SEM = 0.040, and a mean $AUC_{loss} = 0.87$, SD = 0.16, SEM = 0.033. A paired samples *t*-test confirms the difference since the mean AUC_{gain} is significantly smaller than the mean AUC_{loss}, $t\ (23) = -10.57$, $p = .00$, $r = .91$.

By investigating the individual responses separately (Fig. 2), we see some distinct features that deviate from typical discounting responses. Ten participants (99, 101, 105, 106,

Table 2

Individual AUC_{gain} and AUC_{loss} for Participants in the Experiment

	Discounting			Soda
Participant	AUC gains	AUC losses	AUC difference	choice
99	0.07	1.00	0.87	LL
100	0.52	0.56	0.04	SS
101	0.15	0.99	0.84	SS
102	0.24	0.61	0.37	LL
103	0.03	0.97	0.94	LL
104	0.25	1.00	0.75	LL
105	0.03	0.96	0.94	LL
106	0.50	0.95	0.46	don't like
107	0.10	0.95	0.86	SS
108	0.35	0.88	0.53	don't want
109	0.03	0.96	0.94	no thanks
110	0.10	1.00	0.89	LL
111	0.43	0.83	0.40	LL
112	0.52	0.43	-0.09	don't like
113	0.03	0.79	0.77	LL
114	0.58	0.93	0.35	no thanks
115	0.11	0.91	0.80	LL
116	0.25	0.99	0.74	LL
117	0.03	1.00	0.97	LL
118	0.36	1.00	0.64	LL
119	0.03	0.83	0.81	LL
120	0.03	1.00	0.97	SS
121	0.47	0.71	0.25	no thanks
122	0.03	0.67	0.64	SS
Mean AUC:	0.22	0.87		
SD:	0.18	0.16		

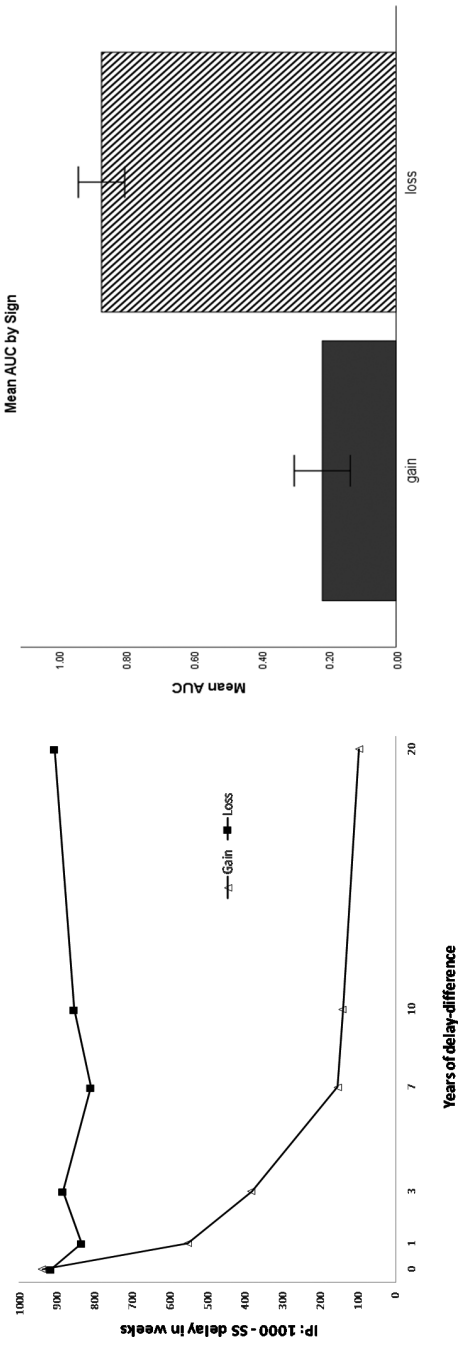


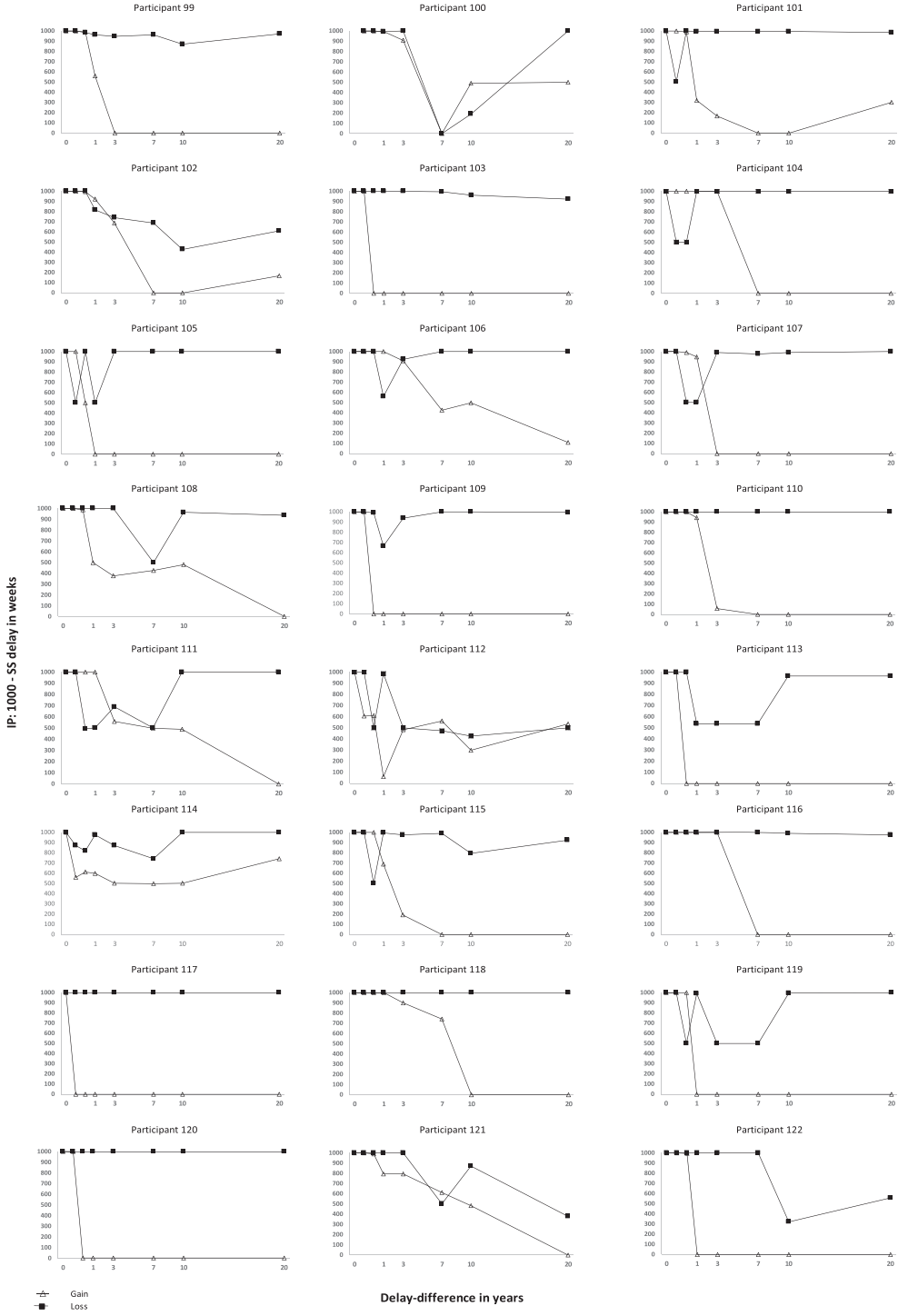
Figure 1
Mean IP Values of Gains and Losses for 24 Participants

107, 108, 110, 111, 115, and 118) showed a gradual devaluation of gains and no, or very little, discounting of losses, as expected. However, eight of the adolescent participants (103, 104, 109, 113, 116, 119, 120, and 122) went from initially choosing LL gain to SS gain in a very abrupt fashion, from one sequence to the next, six of whom did so already between sequence one and two, or two and three. Secondly, as many as 10 participants (100, 105, 106, 107, 108, 109, 111, 113, 114, and 119), were in fact initially discounting losses, but returned to choosing SS losses towards the end. In addition, some *consistently* chose SS loss, so-called zero discounting (110, 117, 118, and 120). Lastly, 10 participants discounted losses somewhat, but much less than how the same participant discounted gains (99, 100, 101, 102, 103, 108, 115, 116, 121, and 122). One of the participants in the current study consistently chose SS loss on every single loss scenario trial, but also consistently chose SS gain on every single gain scenario trial.

In Figure 3 the results from the current study on adolescents are compared to results from the previous study on adults using the same experimental procedure (Furrebøe, 2020). The first panel shows the mean IP values for 24 adolescents and the second panel shows the mean IP values for 31 adults. The AUCs for losses are almost identical (Adult Mean AUC_{loss} = 0.87, SD = 0.21, SEM = 0.04; Adolescent Mean AUC_{loss} = 0.87, SD = 0.16, SEM = 0.03). However, the AUC_{gain} is smaller, meaning steeper discounting, for adolescents than for adults (Adult Mean AUC_{gain} = 0.38, SD = 0.31, SEM = 0.06; Adolescent Mean AUC_{gain} = 0.22, SD = 0.20, SEM = 0.04). An independent-samples test indicated that the discounting of gains was significantly steeper among adolescents compared to adults, t (51) = - 2.28, p = .03, r = .3.

The results from the real-outcome–real-time part of the experiment show that 13 out of the 18 participants who did want the soda, chose the LL alternative. However, it was unreasonable to attempt a comparison of these results to the hypothetical test results for each participant. For different reasons six of the participants neither wanted a glass of soda right away (SS) nor a bottle of soda later (LL). Further, most of the participants who ended up choosing SS, did not drink the soda during the task.

Figure 2
Individual Discounting Curves for 24 Participants



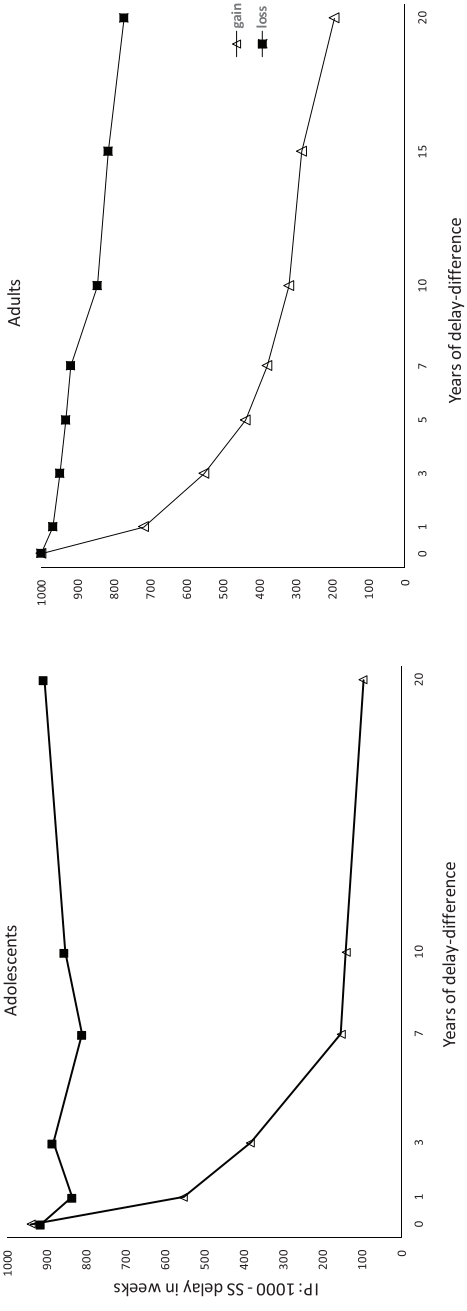


Figure 3
Mean IP Values of Gains and Losses for Adolescents and Adults

Discussion

The aggregate discounting curves and their corresponding area-under-the-curve measures in this experiment support the finding that discounting of gains appears steeper than discounting of losses also among adolescents. The differences are even more profound among these adolescents compared to previously obtained results from adults (Furrebøe, 2020). However, there are features in the results contradicting the discounting paradigm, and consequently the sign effect. Discounting of gains and losses appear qualitatively different, for instance as seen in several individual cases of no discounting of losses. These results indicate a predominant effect of immediacy of the outcome.

The differences in discounting of gains and losses in the current experiment may be explained by qualitative differences. While we see many cases of systematic devaluation of gains, there are altogether few cases of discount of losses in our experiment. Either they abruptly change between alternatives or consistently choose SS loss resulting in zero discounting and a flat curve. Neither of these cases involve a systematic devaluation and cannot be defined as discounting. Previous studies (Myerson et al., 2017) show similar results. Although they investigated immediate outcomes versus delayed outcomes, they also found some of the same individual differences: "conventional" discounting, negative discounting, and those who consistently chose the smaller loss. Hardisty et al. (2013) also reported higher discount rates for gains but lower discount rates for losses, and explained this in terms of present bias. People want to "resolve" issues, also losses, right away. However, they found that this desire was not as strong as the magnitude effect. Thus, people deal with small losses right away, but may postpone larger losses. Present bias may have had a similar impact on the loss scenario results in the current study. The earlier outcome, regardless of sign, has an effect on intertemporal choices.

The steep discounting of gains in our aggregate data is also partly due to the significant number of participants who changed preferences very abruptly. Nine out of the 24 of the adolescent participants changed from exclusively choosing LL alternatives to exclusively

choosing SS alternatives between one sequence and the next. As for the loss cases, per definition this is not discounting, but dichotomously preferring one or the other. This behavior resembles the dichotomous choice pattern that was prevalent among the younger participants in one of the earlier delay of gratification studies (Mischel & Metzner, 1962). A dichotomous choice pattern is an indication of the importance of immediacy to the outcome over a long-term devaluation consideration. There seems to be, for these participants, a choice between one outcome being immediate or close and another one being far away, but how far away is less important. In comparison, adult participants in the similar discounting test (Furrebøe, 2020) for the most part showed a gradual devaluation across several sequences in the case of gains. The discounting-of-losses pattern also appeared *qualitatively* different from that of adults. Ten of the adolescent participants started out discounting losses but went back to choosing the SS loss as delay difference increased, whereas adults normally would continue the initial discounting or never start discounting at all. This could be an indication that these adolescents lack a well-established pattern of choice behavior that the adults demonstrate.

Myerson et al. (2017) explain the variations in discounting-of-loss behavior by personality traits. It is also suggested that there are different systems involved in discounting of gains and losses (Estle et al., 2006; Gonçalves & Silva, 2015). I would argue that there are different competing reinforcing contingencies in the same behavioral system. There are many competing reinforcing contingencies involved in any choice behavior, but studies have found that some contingencies are more persistent than others. For instance, contingency-shaped behavior may overrun rule-governed behavior when one out of two positive outcomes appear immediately (Hayes et al., 1986; Kudadjie-Gyamfi & Rachlin, 2002). Also, a choice situation probably concerns both avoidance or escape of some aversive outcome—a loss, and gratification of a gain (Mischel & Metzner, 1962). For instance, giving in to the tempting candy or money may at the same time mean you are ending the aversive waiting time. The same might be the case for a loss—you do not want to face the loss, but you do want to end the wait, which is a different loss/negative outcome. Thus, I would argue that it is not necessarily the sign of the outcome which dictates choice behavior, but the competing reinforcing contingencies involved.

Previous studies (Baker et al., 2003; Benzion et al., 1989; Gonçalves & Silva, 2015; Johnson et al., 2007; Mitchell & Wilson, 2010) have supported the sign effect on an individual level as well as on an aggregate level. The results from the current study also support the sign effect in the sense of a significant difference in devaluation of delayed outcomes, although in the case of losses the results oppose the discounting paradigm. The sign effect itself seems to be due to differences in competing reinforcing contingencies involved in discounting of gains versus discounting of losses, often resulting in zero discounting or close to zero discounting of losses. Zero discounting is in line with previous studies indicating that people hasten a loss because they want to get it over with (Hardisty et al., 2013; Mischel et al., 1969), a behavior peculiar to humans (Ainslie, 2010).

The major limitation of this study is the procedure. The particular "double-delay" procedure may have contributed to the lack of discounting found in many of the cases. In addition, there is a lack of precision in the titration procedure, as well as a relatively narrow range of delays tested, which may have had an effect on the seemingly more abrupt changes, and in general have limited the information obtained about the causes of discounting. The abrupt changes could also be explained by the lack of randomization of conditions. Although results from studies using randomized conditions also show negative or zero discounting, they tend to show less abrupt changes (Hardisty et al., 2013; Myerson et al., 2017). Another concern is the use of hypothetical questions, which prevents us from gaining causal explanations. Relevant factors influencing discounting may not be directly observed. For instance, the competing reinforcing contingencies may be different in receiving money compared to paying a fine (Furrebøe, 2020). For future research, the qualitative differences in discounting of gains and losses should be explored further, using refined "double-delay" procedures. It would also be interesting to explore devaluation of

delayed losses where the outcomes involved more *effort* than they do in the current study.

Conclusion

Increasing our knowledge about the mechanisms and causes of discounting of gains and losses, in particular for adolescents, is important for a range of different areas of life: education, health, or addictive behavior such as substance abuse, gambling or eating disorders. For instance, some problem behaviors are associated with steep discounting. Refined discounting tasks may have the potential as assessment tools and behavioral treatment approaches that will improve both performance and general well-being for school children, adolescents and adults. However, to effectively deal with such challenges, whether preventing behavior or designing assessment tools or treatments, we need to know the mechanisms of discounting. Disclosing the profound difference in discounting of gains and losses might be a step in this direction. The fact that most adolescents and adults do not seem to discount losses at all in particular situations, indicate little or no sensitivity to delay of certain losses, and that, for instance, interventions involving threats of future negative outcomes may have a very different effect on behavior than potential positive outcomes.

Investigating the origins of the sign effect by means of single-subject studies concerning the qualitative and quantitative differences in discounting, is only a small part of the bigger picture. Future research should also consist of more longitudinal studies in order to investigate the development of discounting of gains and losses, future orientation and self-control in adolescents. These approaches should give us further insight into how discounting of gains and losses differs and how it develops. This research is perhaps particularly important in relation to such areas as health-related behavior or academic competence, and finding good strategies to systematically teach more adaptive ways to deal with choices.

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