HOW CHILDREN REASON ABOUT GAINS AND LOSSES: 
FRAMING EFFECTS IN JUDGEMENT AND CHOICE

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ABSTRACT

Three experiments considered how the positive or negative framing of decisions affects children’s EV judgements and choices. In Experiment 1, 6- and 9-year-olds chose between a sure gain and gamble or between a sure loss and gamble, all with the same EV. Children preferred the sure thing more in the positive than negative frame, as also appears for adults. In Experiment 2, both frames involved potential losses, i.e., what could be saved or lost from an endowment. In their judgements, 6- and 9-year-olds used the normative multiplication rule for integrating risk and amount at risk, with minor frame differences, but when choosing between the same options, they were risk-averse in the save, risk-seeking in the loss frame. In Experiment 3, 5-year-olds used multiplication for saves, with an irregular pattern for losses. Overall, children’s judgements conform closely to normativity, although 5-year-old’s skills were fragile. At the same time, children’s choices, like adults’, show non-normative framing effects. This décalage may reflect the involvement of more intuitive processes in judgement than choice.

Keywords:
Framing effects, Information integration theory, children, judgement and decision
INTRODUCTION

Judgement and choice under uncertainty are basic to everyday cognition and there has been much interest in the principles that guide them. Normatively, a rational decision-maker should always act so as to maximise Expected Value (EV), defined as the multiplicative conjunction of goal value and the likelihood of attaining it (von Neumann & Morgenstern, 1944). This model lies at the core of many approaches to human decision-making (Baron, 2000; Plous, 1993) and motivation (Feather, 1982).

The present studies consider children’s intuitive EV concept: They are surprisingly good at EV judgement, in contrast to the shortcomings reported in adult decision-making (e.g., Kahneman, Slovic & Tversky, 1982). The present studies explore two questions: First, how children reason about losses, framed positively or negatively; second, how their judgements relate to choices about the same uncertain situation.

In the traditional view, multiplicative concepts, such as EV, are beyond the reach of pre-adolescents (e.g., Inhelder & Piaget, 1958). However, recent work using Information Integration Theory (Anderson, 1981, 1982, 1991, 1996) has shown that 4-year-olds make multiplicative EV judgements, with 5-year-olds even considering the contributions of two outcomes (Anderson, 1980; Schlottmann & Anderson, 1994; Schlottmann, 2000; 2001; Schlottmann & Christoforou, 2005).

That even pre-schoolers take into account both probability and goal value agrees with research on other multi-dimensional concepts. Much work on quantitative concepts such as area (e.g., Anderson & Cuneo, 1978; Wolf & Algom, 1987), time (e.g., Wilkening, 1981), density (Cuneo, 1982), probability (e.g., Anderson & Schlottmann, 1991), and on social/psychological concepts, such as moral responsibility and deservingness (Leon, 1982; Anderson, & Butzin, 1978) or likableness of persons and toys (Butzin & Anderson, 1973; Hendrick, Franz & Framing Effects in Children

Hoving, 1975) has convincingly shown that young children do not generally centre, but are quite capable of considering two informational dimensions at once.

Multiplicative EV in pre-schoolers is exceptional, however: In the tasks just cited, children under 8 years integrate the informers additively even if multiplication is normative (Anderson & Cuneo, 1978, Wilkening, 1981, Cuneo, 1982.) Nevertheless, multiplicative EV at younger ages is replicable (Anderson, 1980; Schlottmann & Anderson, 1994, Schlottmann, 2001; Schlottmann & Christoforou, 2005).

One might surmise that children have much experience with EV and that this might lead to precocious performance. Children’s goals, just like adults, are typically uncertain, providing much opportunity to learn about EV in their everyday life. Whether they have more opportunity to learn about EV than about basic physical concepts, such as area and time, however, is debatable.

Alternatively, EV might be a particularly simple multiplicative concept: In EV, probability weights the value of the goal, but the resultant is still a notion of value. In many other cases, in contrast, the two component concepts are conjoined to form a third, new dimension, for instance, velocity = time/distance. Weighting concepts thus may involve less abstraction than conjunctive concepts and this may allow children to use a more complex operator. Regardless of the precise explanation, it is clear that children from age 4 make exceptionally sophisticated EV judgements.

In the present studies, we consider whether children’s facility with EV extends to negative situations involving losses. In previous studies, children encountered situations in which they (or a puppet) could win various prizes, i.e., they faced wholly positive set-ups in which they could only gain. There are at least two reasons, however, to consider losses as well: First, thinking about potential losses may be emotionally more taxing than thinking about gains, involving feelings of anticipated
regret or disappointment (e.g., Connolly & Zeelenberg, 2002; Mellers, Schwarz & Ritov, 1999), as well as inducing conflict (Lopes, 1987). This in turn may strain children’s processing resources and lead to a less mature approach than for gains. Second, in scenarios with a potential risk or danger to self, goods or lives, adults are strongly affected by whether the decision options are portrayed positively or negatively (Tversky & Kahneman, 1981). Such framing effects should be considered in children as well. We cannot compare child and adult judgement / decision unless comparable situations and tasks are studied.

A major difference between work with adults and children in this area is that research with adults usually concerns choice, the ability to select the best of two or more options. The Information Integration work with children, in contrast, considers judgement, the ability to give an estimate of just how good a particular option is. Adult judgement and choice under risk do not usually coincide well (Payne, 1982; Lichtenstein & Slovic, 1971), and discrepancies between judgement and choice also appear with children (Wilkening & Anderson, 1991). In the present work, therefore, we consider children’s judgements and choices, both in gain and loss situations, modelled on a standard decision-making task described below.

**FRAMING EFFECTS**

Preference shifts when identical decision options are framed differently were first reported in Tversky & Kahneman’s (1981) work on the “Asian Disease Problem”. People heard about the outbreak of a disease expected to kill 600 people, then had a choice between two programmes to combat it. If programme A is adopted 400 people will die, but if B is adopted there is a 1/3 chance that no one will die and a 2/3 chance that all will die. The options are equal in EV, yet adults prefer B -- risk-seeking.

Another group hears about programmes C and D: If C is adopted, 200 people will be saved, but if D is adopted there is 1/3 chance that all are saved and 2/3 chance that none are saved. Now people prefer C -- risk-aversion. Actually, all four options have equal EV, yet preferences shift from risk-aversion in the positive to risk-seeking in the negative frame. Similar framing patterns have since appeared in many different contexts (see review in Kühberger, 1998; Levin, Schneider & Gaeth, 1998).

In Kahneman and Tversky’s prospect theory (1979) framing effects occur, because the utility curve for values coded as gains is seen as concave, leading to risk aversion, while for losses it is convex and steeper, leading to risk seeking. Whether this is the best account is unclear – a few simple choices yield little information about underlying process. Regardless of the mechanisms involved, however, choices are clearly inconsistent across frames. Preferences should not be affected by superficial features, such as how equivalent options are described. For Kahneman and Tversky, and other proponents of the biases and heuristics approach to decision-making, frame effects demonstrate the irrationality of the human mind.

The first study of framing in children (Reyna & Ellis, 1994) replaced the written scenarios for adults with visually concrete scenarios: In the positive frame, children chose between winning some balls for sure and playing a gamble of equal EV in which they might win more balls or none at all. In the negative frame, children had an endowment of balls and chose between giving some balls back and a gamble of equal EV in which they might lose more balls or none. On one side of a table, children saw the sure thing, on the other side a bi-coloured spinner for the two probabilities, with the corresponding outcomes placed by them.

Children were generally risk-seeking in both frames, with only a weak indication of a preference shift – in some conditions – for the oldest ones (11 years). Overall, children in this study were far more consistent across frames than adults are -
adults usually show the standard framing pattern described above in both save/loss and gain/loss comparisons (Fagley, 1993). For Reyna & Ellis this means that decision-making becomes more irrational with age: Under Fuzzy Trace Theory (e.g., Brainerd & Reyna, 1993), adults focus on the overall meaning or gist of a situation, but children are more literal and focus on details. While this often leads to inferior reasoning in children (e.g., in class inclusion or conservation, see Brainerd & Reyna, 1993), here it means that they are not misled by the frame information.

Reyna & Ellis’ results suggest that children do not treat losses any differently from gains, at least as far as simple choices are concerned. That children were generally risk-seeking also agrees with prior studies (Schlottmann, 2001; Levin & Hart, 2003) and with the popular prejudice that children are less aware of risks in their lives than adults. Finally, the view that children are rational would seem to fit well with findings of sophisticated EV capabilities in integration studies.

However, an alternative must be ruled out before this account can be accepted: In particular, probabilities and outcomes were visually present throughout the trial, but frame information was not: Winning/losing was acted out and described verbally, but what remained on the table were the balls to be gained or kept – identical for win and loss trials. Children may have focused on this, ignoring the more fleeting frame information. If so, the results do not really compare with adult studies, in which quantitative and frame information are equally salient.

The results contain a second ambiguity: Children’s behaviour should be called risk seeking only if they actually considered the risk in the gamble and compared it to its absence in the sure-thing. Reyna & Ellis (1994) manipulated risk, but the youngest age group showed no effect of this, with small effects for older children. Accordingly, children may largely have focused on the value of the options, ignoring risk. The

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game always has the best potential outcome (gain large number / keep endowment), thus value centration can account for the results as well as risk seeking.

To resolve these issues, Experiment 1 reconsiders children’s choices between a sure thing and a gamble in both positive and negative frames, when quantitative and frame information is equally salient. In Experiment 2, we develop an EV judgement task that is framed positively and negatively, in addition to eliciting choices. Because choice options are taken from the stimuli of the judgement task, we can compare framing effects in the two tasks directly. Both Experiments 1 and 2 involve 6- and 9-year-olds. Experiment 3 extends the investigation to 5-year-olds.

EXPERIMENT 1

Children chose between a gamble and a sure thing of equal EV, presented as gains or losses. To motivate this, children helped a puppet decide which way of sharing jellybeans between puppet and experimenter was better for the puppet. In the gain frame, the jellybeans belonged to the experimenter and the puppet could take some for sure or gamble to win all or none. In the loss frame, the jellybeans belonged to the puppet and she could give away some for sure or gamble to lose all or none. Choice options and frames were presented verbally and visually: Potential gains were placed on a mat with a smiley face. Potential losses were placed on a mat with a frowning face. This approach to the loss frame differs from Reyna & Ellis (1994) who displayed outcomes, i.e., what might be kept, rather than what might be lost.

METHOD

Subjects. Twenty-eight children participated. The younger age group included 6 girls and 8 boys between 6-4 and 7-5, with a mean age of 6-6, the older age group included 8 girls and 6 boys between 8-11 and 10-4 with a mean age of 9-4. The children were predominantly Caucasian, volunteers at a primary school of middle
class character. All had previously participated in a different study on EV judgement (Schlottmann, 2001, Exp 2), with the present choice trials appended at the end.

Design. There were two scenarios, one with an Ev of 4 jellybeans and a risk (in the gamble) of .75, the other with an Ev of 8 jellybeans, and a lower risk of .5. Each scenario involved a gain and a loss trial (see Table 1). All four trials were given in a row. Children were tested individually, with the order of scenarios and frames approximately counterbalanced within each age group.

Table 1: The trial structure of Experiment 1

<table>
<thead>
<tr>
<th>Frame</th>
<th>Scenario</th>
<th>Choose the Sure Thing…</th>
<th>…or the Gamble</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain</td>
<td>EV = 4</td>
<td>Sure gain of 4 jellybeans</td>
<td>.25 probability of winning all 16 and .75 probability of winning none</td>
</tr>
<tr>
<td></td>
<td>High risk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss</td>
<td>EV = 4</td>
<td>Sure loss of 12 jellybeans (of endowment of 16)</td>
<td>.25 probability of losing none and .75 probability of losing all 16</td>
</tr>
<tr>
<td></td>
<td>High risk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gain</td>
<td>EV = 8</td>
<td>Sure gain of 8 jellybeans</td>
<td>.5 probability of winning all 16 and .5 probability of winning none</td>
</tr>
<tr>
<td></td>
<td>Low risk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss</td>
<td>EV = 8</td>
<td>Sure loss of 8 jellybeans (of endowment of 16)</td>
<td>.5 probability of losing none and .5 probability of losing all 16</td>
</tr>
<tr>
<td></td>
<td>Low risk</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Materials. The two options in each trial were displayed on yellow A4 mats with smiley faces (5 cm diameter) in the gain frame (Figure 1), or on blue mats with frowning faces in the loss frame. The experimenter (E) sat on one side, child and puppet (Lucy Lemur) on the other, with the sure thing on the child’s left, the gamble on the right. A paper strip on each mat illustrated the risk; bags of jellybeans showed the potential gains/losses. When Lucy could win, these bags were removed from other bags kept on E’s side to make the gain salient. When Lucy could lose, the bags were removed from other bags kept on the puppet’s side to make the loss salient.

All bags of jellybeans initially contained 16 beans of mixed colour. Four or 8 of these, wrapped in cellophane, were taken out to indicate the sure gain or loss. For the gain/lose all option of the gamble, a second bag containing all16 beans was taken out of the original bag, leaving an empty bag behind. For the gain/lose none option of the gamble, an empty bag was taken out, leaving a full bag behind.

Figure 1: The stimulus display for a gain trial in Experiment 1; see Table 1 for the actual numbers of jellybeans placed on each side for each trial

Risk was illustrated with a game that children knew from the prior task (Schlottmann, 2001). A marble was shaken in a clear tube inset with a bi-coloured paper strip. If the marble landed on yellow, Lucy would win all/lose no jellybeans, but if it landed on blue, she would win none/lose all of them. Thus yellow was associated with winning, blue with losing. After demonstration of the tubes, experimental trials involved only the paper strips (“so the marbles don’t roll around and make a mess”).

Risk level was manipulated by varying the length of the paper strips, with each strip composed of 5 x 3 cm units. The paper strip had 1 yellow and 3 blue units (EV = 4), 2 yellow and 2 blue units (EV = 8), 2 yellow units (sure gain) or 2 blue units (sure loss).

Procedure. Children heard that both Lucy and E loved jellybeans and that they would have to share. Sometimes E had a bag of jellybeans and had to share with the puppet, so Lucy would get some and this would make her happy (E pointed to smiley face). Sometimes Lucy had jellybeans and had to share with E, so she would lose some, and this would make her sad (E pointed to sad face). Children were told that there were different ways of sharing and that their job was to help the puppet choose the best way. Then the first trial was introduced.
On gain trials, E had the jellybeans and Lucy could choose one of two things: She could take 4 (or 8) jellybeans for sure which were removed from E’s bag and placed on the left mat by the all-yellow strip. Or she could play the game illustrated by the strip on the right mat. If the marble landed on yellow, Lucy would win all the beans, but if it landed on blue, she would win none, with full and empty bags placed by the yellow and blue segments, respectively. Children then recounted the options. (“If she chooses this side, what will happen?”) All could do this. Then they indicated which side Lucy should choose. Loss trials were explained correspondingly: Lucy could give 12 (or 8) of her jellybeans away or play the tube game. If the marble landed on yellow, she would lose nothing, but if it landed on blue, she would lose all.

RESULTS

The results show standard framing: Children chose the sure thing in 89% of gain and 46% of loss trials (Table 2). There was strong risk aversion in both gain scenarios. There was also a clear shift towards more risky choices for losses, but the proportion of risk-seeking choices did not differ from chance in either scenario. Risk-aversion in the positive frame can be more pronounced than risk seeking in the negative frame for adults as well (Schneider, 1992). Our results do not replicate Reyna & Ellis’ (1994) finding that children are risk-seeking overall.

<table>
<thead>
<tr>
<th>Frame</th>
<th>Scenario</th>
<th>Sure Thing</th>
<th>Gamble</th>
<th>% Sure Thing Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>6 years</td>
<td>9 years</td>
</tr>
<tr>
<td>Gain</td>
<td>EV = 4</td>
<td>Win 4 jellybeans for sure</td>
<td>.25 prob of winning 16</td>
<td>86 *</td>
</tr>
<tr>
<td></td>
<td>High risk</td>
<td>.75 prob of winning none</td>
<td>79 *</td>
<td>93 *</td>
</tr>
<tr>
<td>Gain</td>
<td>EV = 8</td>
<td>Win 8 jellybeans for sure</td>
<td>.5 prob of winning 16</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Low risk</td>
<td>.5 prob of winning none</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>Loss</td>
<td>EV = 4</td>
<td>Lose 12 (of 16) jellybeans for sure</td>
<td>.25 prob of losing none</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>High risk</td>
<td>.75 prob of losing 16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss</td>
<td>EV = 8</td>
<td>Lose 8 (of 16) jellybeans for sure</td>
<td>.5 prob of losing none</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low risk</td>
<td>.5 prob of losing 16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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A mixed model ANOVA on the percentage of sure thing choices found a main effect of Frame, F(1,20) = 22.47, MSE = 5.13, p < .001, that depended on the scenario, F(1,20) = 5.49, MSE = 27, p = .030, with less of a frame difference under high risk, perhaps due to a ceiling effect. There were no age differences, all F < 1, and no effects of stimulus order, F(1,20) < 1.84. The Frame effect was significant when each scenario was analysed separately, F(1,20) = 11.80, MSE = 1.52, p = .003 and F(1,20) = 26.17, MSE = 3.87, p < .001, for the more and less risky scenarios, respectively. Sign tests confirmed that children chose the sure thing more in gain than loss trials, p = .004 and p < .001, for the higher and lower risk scenarios, respectively.

Standard framing was also the most frequent pattern for individuals. Nine children showed a preference reversal, with sure thing choices in both gain trials and gamble choices in both loss trials, and 6 further children showed a preference shift, with sure thing choices in both gain and gamble choices in one loss trial (always the less risky scenario). Eight children were consistently risk averse and one was risk seeking. The remaining 4 children were risk averse for one scenario and risk seeking for the other. There were no apparent age differences in the individual patterns.

DISCUSSION

In Experiment 1, 6- and 9-year-olds treated gains and losses differently, showing standard framing in risky choice. We found strong risk aversion for gains that shifted towards risk seeking for the same options presented as losses. This pattern is adult-like, including the finding of stronger preferences for positive frames (Schneider, 1992). Our results fit with Levin & Hart (2003) who also found a preference shift when 6-year-olds chose which game they wanted to play (rather than making choices for a puppet.) Our results contrast with Reyna & Ellis’ (1994) report of consistent choices across frames. Fewer trials, clearer task structure, and visual presentation of frame information throughout each trial may have contributed to the more mature data pattern here.

Children encountered the framing task at the end of another study involving judgement rather than choices for gains (Schlottmann, 2001, Exp.2). We studied risk
attitudes in both tasks, but there was little correspondence. This could, however, be due to dissimilarity in stimulus structure or in the way that risk attitudes were operationalised, highlighting the need to study judgement and choice in a way that allows direct comparison. This was a main goal in Experiment 2.

A second goal was to address an ambiguity in the interpretation of Experiment 1. Although children displayed a standard framing effect, this could be confounded with an endowment effect (e.g., Thaler, 1980): People tend to price things they already own higher than the price they are willing to pay for the same goods if they do not yet own them. Harbaugh, Krause & Vesterlund (1999) have also demonstrated this bias in children between 5 and 10. In the present study, as well as in Reyna & Ellis (1994) and Hart & Levin (2003), children were given an initial endowment in the loss, but not gain frame; technically these studies concern reflection rather than framing effects (Fagley, 1993). The difference in endowment, rather than difference between loss and gain per se, could also account for children’s differential responses to the two frames. Experiment 2 seeks to overcome this problem.

**EXPERIMENT 2**

Experiment 1 suggests that, in their choices, young children treat situations described positively differently from those described negatively – in their choices. Here, we consider whether framing effects also appear in judgement, and whether they take similar form in judgement and choice. To compare, children make judgements and choices about parallel situations, with identical options in both response modes.

To unconfound framing and endowment effects, children encounter a potential loss, facing a risk to an endowment, in both frames. In the positive frame, outcomes are described in terms of what may be saved, but in the negative frame outcomes are described in terms of what may be lost. This is modelled on the Asian Disease Problem (Tversky & Kahneman, 1981), the prototypical framing problem for adults.

In the judgement task, children simply estimate, on a graphic scale, how happy the puppet is with particular games. In previous studies of gain situations, their judgements of happiness had the structure predicted by the EV model (Anderson, 1980; Schlottmann & Anderson, 1994; Schlottmann, 2001). In the present study children evaluate single options in which the puppet can lose or save various amount of jellybeans at risk, with variable risk illustrated by tube games, as before. Some of the single options encountered in this judgement task (which includes sure losses) then are also used as decision alternatives in a choice task, as in Experiment 1. This approach allows direct comparison of preferences in the two response modes.

The normative model for EV of a single option in both frames is

\[ EV = \text{Endowment} - \text{Risk} \times \text{Number at Risk} \] (1)

This expresses EV as the difference between what the puppet owns right now and what she may lose. To see how this equation derives from the basic EV model, consider that overall EV is simply the sum of the component EVs of the yellow and blue outcome in the tube game. With \( P \) and \( (1-P) \) for the alternative blue and yellow probabilities, and \( V \) for the associated values,

\[ EV = P \times V_{\text{blue}} + (1-P) \times V_{\text{yellow}} \] (2)

If yellow comes up, as before, the puppet saves all her jellybeans/loses none, but if blue comes up, she saves only some/loses some. The blue probability therefore constitutes the risk. Thus, the equation may be rewritten as

\[ EV = \text{Risk} \times \text{(Endowment} - \text{Number at Risk}) + (1-\text{Risk}) \times \text{Endowment} \] (3)

Written out, and with cancellation of terms, Equation 3 becomes Equation 1.

This normative model, for the parameters of the present design, is shown in Figure 2. (Ignore the circled options for now). EV decreases as the risk of not saving / losing some jellybeans increases towards the right (horizontal). EV also decreases with the number of jellybeans at risk (curve factor). The multiplication of the factors appears in the linear fan pattern: When few of the jellybeans are at risk, even not saving/losing them for sure does not decrease overall EV by much, but when all are at risk, it decreases overall EV to zero. Thus the curves diverge towards the right – and they would converge completely on the left if there were no risk at all.

The normative model here shows objective values, but children’s judgements are not numerically exact. Under the Information Integration approach, children are
discouraged from using counting and other precise strategies, which can give rise to numerical biases (Anderson, 1982). Fortunately, intuitive estimates of risks and values suffice for strategy diagnosis. In particular, if children use multiplication for combining the two, the curves will always take a linear fan shape, regardless of what the estimates of risk and value are (Anderson, 1981). Other integration strategies generate different patterns. An additive strategy, for instance, yields parallel lines, while under a centration strategy only one of the factors manipulated will show an effect. Thus a major advantage of the Integration approach is that it allows us to separate an understanding of the functional relations between risk and goal value from the ability to determine numerically correct parameter values.

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corresponding gambles circled on the left. Risk seeking would appear if the sure options were judged lower than the gambles. This could be due to non-multiplicative integration, but might appear even if children use multiplication: With risk aversion, for instance, the all-at-risk curve (bottom) may be steeper or lie lower than predicted, or the other curves may be flatter or higher, or the sure thing options alone are judged exceptionally high. The present approach not only allows comparison of positive and negative frames, and of judgements and choices, but may also yield insight as to whether risk attitudes reflect non-normative integration or evaluation of options.

**METHOD**

**Subjects.** Thirty-two children participated, 8 younger girls and 8 boys between 6-4 and 7-3, with a mean age of 6-10, and 7 older girls and 9 boys between 9-4 and 10-2, mean age 9-9. Children were from the same general population as in Experiment 1, but had not participated before. They were tested individually in two sessions of about 35 minutes each, separated 5 to 7 days.

**Design.** For the older children, the judgement task had a 4 risk (1, .75, .5, .25) x 4 number-at-risk (all 20, 15, 10, 5 jellybeans) x 2 frames (save, lose) within subjects factorial design. Fearing fatigue at the younger age, we omitted the lowest risk level and smallest number at risk, yielding a 3 x 3 x 2 design. Children judged two individually randomised replications of the stimuli for each frame.

The choice task involved a loss and a gain trial for each of 3 scenarios with different overall EV/level of risk in the gamble, as shown in Figure 2. For the younger children, due to the reduced judgement design, there were comparable judgement data only for choice pairs 2 and 3 at the bottom of Figure 2.

Age, frame order and task order were additional between subjects variables. Half of the children at each age encountered the positive frame in the initial session, half the negative frame. Within this, half of the children gave judgements followed by choices, half gave choices followed by judgements.

![Figure 2: EV predicted by Equations (1) to (3) for the design of Experiment 2.](image)
Materials. Risk was again illustrated with the tube game. Tubes with marbles and paper strips of ratio 1:5, 3:3 and 5:1 units (yellow-blue ratio) were used during instruction. Corresponding paper strips without tubes were used for the practice. Strips with different ratios were used for experimental trials in both tasks, with a 2 unit all blue strip for a risk of 1, 1:3 for .75 risk, 1:1 for .5 risk and 3:1 for .25. In this way children were not trained on the experimental stimuli, nor was the response to risk confounded with a response to the length of the risky blue segment.

Bags of jellybeans initially contained 20 beans, the puppet’s endowment on each trial. Smaller bags containing 0, 5, 10, 15 or all 20 jellybeans were removed from the full bag to illustrate the number to be saved/lost. To make numbers maximally distinct different size bags were used, with smaller numbers contained in smaller bags.

For judgement trials, a single A3 mat was used, yellow to the left of the child, blue to the right. Paper strips were placed so that each colour rested on the corresponding part of the mat. For choice trials, the other side of the mat had a thick black line separating the top and bottom half (Figure 3). The sure thing was displayed on the top (further away from the child), the gamble on the bottom.

Children used a graphic scale for their judgements. It had 17 wooden sticks, increasing in height from 2.5 to 18.5 cm, in 1 cm steps. The child pointed to a stick to show how happy the puppet would be, with bigger sticks for better games. Children can use such scales in a linear fashion (Anderson & Schlottmann, 1991; Schlottmann & Anderson, 1994). Appropriate scale usage was elicited in the standard way by instruction with end anchors (Anderson, 1982; see below).

Procedure. Children met Lucy Lemur with her box of jellybeans. Lucy’s mum had decided that she could have one bag each day, but would have to share with E, a prospect that made Lucy sad. To make sharing more fun, Lucy could play sharing games to decide how many she could keep/lose (depending on the frame). Some games were good, others not so good, and Lucy needed a clever child to show her just how good each game was.

Then the amounts to be kept in the positive frame (0, 5, 10 15) or to be lost in the negative frame (20, 15, 10, 5) were introduced by pulling small bags out of big bags. Children indicated which amount to be kept/given away would make Lucy happiest and which would make her saddest. They also sorted the bags according to how happy Lucy would be if she could keep/would lose this amount.

Next the tube games were introduced and children saw that it is easier for the marble to land on yellow if there is more yellow, easier to land on blue if there is more blue. Thus the 5:1 tube was best for landing on yellow, the 1:5 tube for landing on blue and the 3:3 tube was ok for both. This instruction unfolded in question-and-answer style and it was clear that all children understood how the tube worked.

Then tubes and jellybeans were put together. If the marble landed on yellow, Lucy could keep all/lose none of her jellybeans, but if blue came up, she could keep only some/lose some. A 5:1 sample game, in which Lucy could keep all/lose none of her jellybeans on yellow, but would keep none/lose all on blue was then shown. When asked if this game would make Lucy happy, all said yes, and knew that it was easy for
Lucy to save all/lose none of her jellybeans. Then the 1:5 and 3:3 tubes were used, resulting in games that made Lucy progressively sad.

The stick scale was introduced next. A bag of 20 jellybeans/empty bag was placed by the longest stick to indicate that Lucy was happiest if she could keep all / lose none for sure. An empty bag/ bag of 20 beans was placed by the shortest stick to indicate that Lucy was saddest if she couldn’t keep any/would lose all for sure. Then children placed the intermediate amounts to be kept/lost by appropriate middle sticks. These bags were removed right after. The two anchors (full/empty bag) remained by the longest and shortest stick throughout to remind children of the scale orientation.

At this point the procedure diverged, depending on which task came first. For judgement, children rated 9 practice games, starting with a 3:3 configuration with no beans at risk on yellow and all at risk on blue. The practice was arranged such that only risk or only the number at risk changed from one trial to the next. Trials first increased, then decreased in EV, and finally went up again. Then Lucy went for a nap and children proceeded with the experimental trials in randomised order.

If choice came first, children were told they would now see two ways of sharing jellybeans at once and their job would be to tell Lucy “which was better, so that Lucy would know which thing to do”. The scenarios were then presented in random order. After E’s description of each scenario, children recounted the available options, then simply pointed to their preferred option.

After the first task, children were told they had done so well that the game would now be a bit harder and the mat was turned over for the choice trials or practice judgements. In the second session for the other frame, instructions about tube games were abbreviated, but instructions involving the amounts to be kept/lost were run through in full to familiarise children extensively with the new frame.

RESULTS AND DISCUSSION

Choice task. Children showed an even clearer framing pattern than in Experiment 1, with 80% risk averse, sure thing choices in the save frame, but only

Framing Effects in Children

22% in the loss frame. Choices for each scenario and age group are in Table 3. In all scenarios there was a shift from more sure thing choices in the save to more gamble choices in the loss frame. The preference shift was similar for both ages, but depended on the scenario. In both frames, children chose the sure thing most often for the high EV/low risk scenario, and least often for the low EV/high-risk scenario.

Table 3: Children’s choices in Experiment 2 (* indicates that choices differ from chance, $\chi^2, p < .05$)

<table>
<thead>
<tr>
<th>Frame</th>
<th>Scenario</th>
<th>Sure Thing</th>
<th>Gamble</th>
<th>% Sure Thing Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>6 years</td>
<td>9 years</td>
</tr>
<tr>
<td>Save</td>
<td>EV = 5 High risk</td>
<td>Save 5 jellybeans for sure</td>
<td>.25 chance of saving 20</td>
<td>30</td>
</tr>
<tr>
<td>Save</td>
<td>EV = 10 Medium risk</td>
<td>Save 10 jellybeans for sure</td>
<td>.5 chance of saving 20</td>
<td>81</td>
</tr>
<tr>
<td>Save</td>
<td>EV = 15 Low risk</td>
<td>Save 15 jellybeans for sure</td>
<td>.75 chance of saving 20</td>
<td>100</td>
</tr>
<tr>
<td>Loss</td>
<td>EV = 5 High risk</td>
<td>Lose 15 (of 20) jellybeans for sure</td>
<td>.25 chance of losing none</td>
<td>6</td>
</tr>
<tr>
<td>Loss</td>
<td>EV = 10 Medium risk</td>
<td>Lose 10 (of 20) jellybeans for sure</td>
<td>.5 chance of losing none</td>
<td>19</td>
</tr>
<tr>
<td>Loss</td>
<td>EV = 15 Low risk</td>
<td>Lose 5 (of 20) jellybeans for sure</td>
<td>.75 chance of losing none</td>
<td>31</td>
</tr>
</tbody>
</table>

A mixed model ANOVA on the percentage of sure thing choices found main effects of Frame, $F(1,24) = 84.0, MSE = .19, p < .001$, reflecting more sure thing choices in the save frame, and of Scenario, $F(2,28) = 16.44, MSE = .14, p < .001$, reflecting more sure thing choices for higher EV, lower risk scenarios. An Age x Frame Order x Task Order interaction, $F(1,24) = 5.25, MSE = .19, p = .031$, was the only effect involving the between subjects factors and of no substantial interest. Sign tests confirmed that children chose the sure thing more often in the save than the loss frame for all three scenarios, all $p < .001$.

Standard framing was also the most frequent pattern for individuals. Nine children showed a complete preference reversal for all 3 scenarios and a further 20 showed a preference shift, with more sure thing choices in save that loss trials, 1 child
was risk averse regardless of frame, and 2 tended towards risk seeking regardless of frame. No age differences were apparent at the individual level.

Overall, these results replicate Experiment 1, showing clearly that standard framing appears in children’s choices, even when both frames concern a risk to an endowment. The results of the two studies differed, however, in that children in Experiment 1 tended to choose the sure thing more often for the lower EV, higher risk scenario, whereas in Experiment 2 they chose it more often for the higher EV, lower risk scenario, as also appears for adults (Kühberger, Schulte-Meckenbeck & Perner, 1999). In all scenarios of both experiments, however, children were more risk averse in the positive than the negative frame. Children’s choices thus seem no more consistent or rational than adults, contrary to early reports (Reyna & Ellis, 1994).

**EV Multiplication in the Judgement Task.** Children’s judgements are in Figure 4. At both ages, judgements decrease as the level of risk (horizontal) and the amount at risk (curve factor) increase. Most importantly, at both ages and for both frames, judgements diverge towards the right, indicating multiplicative integration of risk and value of the gamble, as normatively required. This extends previous findings of EV multiplication from gain situations to potentially more demanding loss situations.

![Framing Effects in Children](image)

**Figure 4:** The solid lines show children’s mean judgements in two frames as a function of risk level (horizontal) and number at risk (curve factor). The halftone lines repeat the normative predictions of Figure 2. For both ages, the pattern is multiplicative as predicted. Frame differences are small, but judgements tend to be slightly higher in the save frame (left) than the loss frame (right).

The visual impression was confirmed by a 3 risk x 3 amount at risk x 2 frame x 2 age x 2 frame order x 2 task order mixed model ANOVA on judgements for the 3 x 3 design that both age groups shared. This yielded main effects of risk, number-at-risk, and a risk x number-at-risk interaction, $F > 117.27$, $MSE < 1.27$, $p < .001$, with a linear x linear component, $F(1.24) = 909.75$, $MSE = .53$, $p < .001$, that provides a more sensitive test of the fan pattern. The overall interaction differed for the two ages, 1

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1 The two order factors entered in two high order interactions with unclear pattern at the .05 level in the overall analysis. This is no more than expected by chance, and these factors will not be considered further.
F(4,96) = 3.66, MSE = 1.11, p = .008, but the bilinear component did not, F(1,24) = 2.51, MSE = .53, p = .127. Both main effects and the interaction were significant when data for each age were analysed separately, F > 50.21.

In individual ANOVAs, all children had significant risk and number-at-risk main effects, and 15 9- and 12 6-year-olds (of 16 per age) had significant interactions (all p < .05). In every case, the pattern of means indicated some multiplicative divergence, with the means difference between the smallest and largest number-at-risk smaller at the lowest than the highest risk level (corresponding to the left and right, top and bottom points in the graphs of Figure 4). In sum, the evidence for multiplicative EV judgements was clear at both the individual and group level.

Relation to the Normative Model and Frame differences in Judgement. The curve pattern fits well with the normative model (halftone curves), but the small deviations appear systematic: First, the observed curves in Figure 4 are flatter than predicted, except the bottom curves (all at risk). Less slope indicates a smaller risk effect, i.e., children do not give quite enough weight to this factor.

Second, deviations from the predictions are smallest for sure loss games (right points on each curve) and when all are at risk. On average, all-at-risk games were judged .37 too low, sure losses were judged .21 too high, while the other games were judged .91 too low. An anchor effect presumably contributes to perfect agreement for the bottom right point on each graph (excluded from the deviation calculation).

These differences between predicted and observed pattern were reliable, leading to risk and number-at-risk main effects, as well as an interaction, F(3,45) = 15.02, MSE = 1.69, p < .001, F(3,45) = 3.01, MSE = 1.82, p = .040, F(9,135) = 4.58, MSE = 1.49, p < .001, respectively, for 9-year-olds. For 6-year-olds, the risk effect reached F(2,30) = 23.78, MSE = 1.22, and the interaction reached F(4,60) = 9.68, MSE = 1.27, both p < .001, but the number-at-risk effect did not reach significance despite the same trend in the means.

Framing Effects in Children

Frame effects in Figure 4 are small. Multiplication appeared for both frames. The interaction, or its bilinear component, did not differ between them. Thus, there were no frame differences in integration.

There were frame differences, however, in how the options were evaluated: In particular, judgements were slightly higher and closer to the normative predictions in the save than the loss frame, with frame main effects for older and younger children, F(1,15) = 13.47, MSE = 1.22, p = .002, and F(1,15) = 9.76, MSE = 1.30, p = .007, respectively. The single exception to this loss aversion appeared for 6-year-olds, who judged 10 beans to be saved lower than 10 beans to be lost, with F(2,30) = 4.55, MSE = 1.73, p = .019, for the frame x number at risk interaction. It remains to be seen whether a similar pattern of deviations from the normative model, with under-weighting of risk in both frames, and with loss aversion, appears in future studies.

Comparison of Judgements and Choices. The weak framing effects in children’s judgements do not agree with the strong framing effects in their choices. Table 4 shows mean judgements for the 3 choice pairs, as well as choice preferences, thus combining elements of Table 2 and Figure 4.

Table 4: Children’s mean judgement and % choice preferences for 3 choice pairs. (* indicates that the judgement preference for the sure thing or gamble is significant at p < .05, * indicates that choices differ from chance, x², p < .05, ns indicates a non-significant preference)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Sure Thing</th>
<th>Gamble Judgement Preference</th>
<th>Choice Preference (% Sure Thing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Save</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High risk</td>
<td>4.63</td>
<td>3.44</td>
<td>Sure Thing *</td>
</tr>
<tr>
<td>Medium risk</td>
<td>8.69</td>
<td>8.03</td>
<td>Sure Thing *</td>
</tr>
<tr>
<td>Low risk</td>
<td>12.19</td>
<td>11.97</td>
<td>Sure Thing *</td>
</tr>
<tr>
<td>6 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High risk</td>
<td>4.84</td>
<td>3.31</td>
<td>Sure Thing *</td>
</tr>
<tr>
<td>Medium risk</td>
<td>8.78</td>
<td>8.00</td>
<td>Sure Thing *</td>
</tr>
<tr>
<td>Low risk</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>9 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High risk</td>
<td>3.56</td>
<td>2.97</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td>Loss Medium risk</td>
<td>Loss Low risk</td>
<td>6 years High risk</td>
</tr>
<tr>
<td>----------</td>
<td>------------------</td>
<td>---------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Medium</td>
<td>7.91</td>
<td>8.13</td>
<td>ns</td>
</tr>
<tr>
<td>Low</td>
<td>11.59</td>
<td>11.16</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ns</td>
<td></td>
<td></td>
<td>50 ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the save frame, both ages show risk aversion for judgements. Sure saves are judged significantly higher than equivalent gambles. This reflects the under-weighting of risk when some, but not all beans are under threat, already discussed in relation to Figure 4. Children’s judgements predict generally risk-averse choices, as observed, but not the extent to which the sure thing is preferred: Row 3 of the table shows the smallest judgement preference, but 100% choice preference. Row 4 shows the largest judgement preference, with 50% sure thing choices. Thus, the strength of children’s judgement preference does not predict the strength of their choice preference.

For losses, judgement preferences in Table 4 are less clear. Nine-year-olds have no significant preferences, while 6-year-olds prefer the sure thing in one pair and the gamble in the other. Figure 4 showed similar under-weighting of risk for both frames, but any resulting sure thing preference for losses seems counteracted by loss aversion. The unclear judgement preferences contrast with clear choice preferences for the gamble for losses. Overall, the two response modes correspond in the direction of the preference shift, but not in preference strength.

Finally, we compared response patterns in both tasks at the individual level (Table 5). Signs of standard framing appeared when we considered whether ratings were simply higher for the sure thing or the gamble: The majority (n = 22) preferred the sure thing more often in the save than loss frame, as also found in the choices (n = 29). Moreover, 20 children showed standard framing in both tasks. Still, preferences agreed only on 54% of individual save and 38% of loss trials. Again, framing effects in judgement and choice appear related, but not closely related.

Table 5: Cross-tabulation of response patterns in the two tasks. (Standard Framing: More sure thing choices in save than loss frame; Reverse Framing: More sure thing choices in loss than save frame; Risk Aversion: More sure thing choices regardless of frame; Risk Seeking: More gamble choices regardless of frame)

<table>
<thead>
<tr>
<th>Choices → Judgements</th>
<th>Standard Framing</th>
<th>Reverse Framing</th>
<th>Risk Aversion</th>
<th>Risk Seeking</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Std. Framing</td>
<td>20</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>22</td>
</tr>
<tr>
<td>Reverse Framing</td>
<td>7</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Risk Aversion</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Risk Seeking</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>-</td>
<td>1</td>
<td>2</td>
<td>32</td>
</tr>
</tbody>
</table>

**EXPERIMENT 3**

The good performance of the 6-year-olds in Experiment 2 raised the question of how even younger children would do. Thus in this experiment we considered 5-year-olds’ EV judgements for loss situations.

**METHOD**

This was the same as in Experiment 2, with children making judgements for the same 4 risk x 4 number-at-risk design given only to the older children previously. Due to a procedural error, for some children ratings were recorded on a 16 point scale, for others on a 17 point scale, but the effects of this on the data pattern are negligible.

**RESULTS AND DISCUSSION**

Five-year-olds’ mean judgements are in Figure 5. Frame differences are stronger here than for the older children considered before. A multiplicative fan pattern appears in the save frame. However, in the loss frame the pattern is less regular.

The pattern for the save frame is similar to Experiment 2: First, the curves fan. Thus 5-year-olds’ EV judgements take multiplicative form when the situation is described in terms of what is saved. Second, the curves are slightly flatter than the normative predictions2, indicating some under-weighting of the risk. Third, the fit

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2The normative pattern is based on half of the children using a 16-point scale, half a 17-point scale.
with the normative model seems best for the bottom, all-at-risk curve, and for the sure options on the right. Overall, 5-year-olds’ EV judgements in save situations seem equivalent to those of the 6- and 9-year-olds in Experiment 2.

![Graph showing mean judgement of happiness vs. risk of losing the number specified on the right](image)

Figure 5: The solid lines show 5-year-olds’ mean judgements in two frames as a function of risk level (horizontal) and number at risk (curve factor), with the normative predictions in half tone. In the save frame, the pattern is multiplicative as predicted, but in the loss frame the pattern is less regular.

In the loss frame, in contrast, judgements tend to be lower; the curves are steeper and lie generally much closer together, with the bottom two curves largely superimposed. The curves also show little divergence, except for sure losses on the right. When the situation is described in terms of losses, the youngest children simplify their judgement in a way that is not clearly multiplicative anymore.

The statistical analysis agrees with the visual impression. A 4-way ANOVA found effects of risk, number-at-risk and an interaction, $F(3,54) = 124.57$, $MSE = 13.25$, $F(3,54) = 179.03$, $MSE = 4.52$, $F(9,162) = 13.17$, $MSE = 4.16$, all $p < .001$, as previously described. The risk effect was larger for losses, $F(3,54) = 4.48$, $MSE = 7.44$, $p = .007$, but the number-at-risk effect was smaller, $F(3,54) = 9.58$, $MSE = 3.86$, $p < .001$ and the fan pattern was less clear, $F(9,162) = 1.99$, $MSE = 3.45$, $p = .044$. In addition, there was a frame main effect, $F(1,18) = 17.31$, $MSE = 13.66$, $p = .001$, with lower judgements for losses, and two effects involving frame order: The number-at-risk x frame x frame order interaction, $F(3,54) = 3.95$, $MSE = 3.86$, $p = .013$, reflects a very small number-at-risk effect in the loss frame when this came second. The risk x frame x frame order interaction, $F(3,54) = 3.68$, $MSE = 7.44$, $p = .018$, reflects a very small risk effect in the save frame when this came first.

Both frames showed significant effects of risk and number-at-risk, $F(3,54) = 52.96$, $MSE < 12.64$, $p < .001$. The latter effect was smaller for losses when these came second, as already described, $F(3,54) = 3.30$, $MSE = 4.25$, $p = .027$. The risk x number-at-risk interaction also appeared for both frames, $F(9,162) = 5.42$, $MSE < 4.43$, $p < .001$, but clearly took different shape: When sure losses (right points on the graphs) were omitted from the analysis, the interaction remained significant in the save frame, $F(6,108) = 7.58$, $MSE = 3.13$, $p < .001$, with a significant linear x linear component, $F(1,18) = 16.0$, $MSE = 7.34$, $p = .001$. In the loss frame neither was significant, $F < 1$, and $F(1,18) = 1.92$, $MSE = 4.28$, $p = .183$. Thus 5-year-olds multiply probability and value in the positive frame, but may resort to a simpler approach when the same situation is described negatively.

At the individual level, all 20 children showed significant risk and amount at risk effects and 16 showed a frame main effect, but the ANOVAs had too little power to show the interactions so clear in the group pattern: Only 8 children had an interaction of risk and amount at risk, which differed across frames for only 2. The main effects of risk and amount at risk differed across frames for 6 children each.

Individual means, however, were consistent with the group analysis: All children showed signs of multiplicative divergence and 18 judged save games higher than losses. Fourteen children had a larger number-at-risk effect in the save frame; 11 had a larger risk effect in the loss frame; 13 showed more divergence for saves than losses once sure losses were eliminated. Overall, group and individual analysis agree that 5-year-olds may use somewhat different approaches in the two frames.

When the traditional measure of framing was considered and sure options were compared to gambles of equivalent EV, we found non-significant preferences in all 3...
save pairs, but significant risk seeking in the 2 higher EV loss pairs (Table 6). Thus we found signs of a standard preference shift, as for older children, but for 5-year-olds the trend was towards risk seeking, rather than away from risk-aversion.

Table 6: Five-year-olds’ mean judgement preferences for 3 pairs of sure thing and gamble options of equivalent EV. 1* indicates that the judgement preference for the sure thing or gamble is significant at p < .05, ns indicates non-significant preference

<table>
<thead>
<tr>
<th></th>
<th>Outcome EV</th>
<th>Sure Thing</th>
<th>Gamble</th>
<th>Judgement Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 years Save</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EV = 5</td>
<td>3.98</td>
<td>4.10</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>EV = 10</td>
<td>7.88</td>
<td>7.53</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>EV = 15</td>
<td>11.08</td>
<td>11.25</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>5 years Loss</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EV = 5</td>
<td>3.43</td>
<td>3.98</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>EV = 10</td>
<td>5.28</td>
<td>7.15</td>
<td>Gamble*</td>
<td></td>
</tr>
<tr>
<td>EV = 15</td>
<td>9.17</td>
<td>11.80</td>
<td>Gamble*</td>
<td></td>
</tr>
</tbody>
</table>

OVERALL DISCUSSION

Three experiments investigated how the framing of options affects children’s judgements and choices. Most importantly, we found that children from 5 years are capable of multiplicative EV judgements, even when possible losses are considered. Five-year-olds coped better when problems were framed in terms of what could be saved rather than lost, but framing mattered little from age 6. In contrast, choices were strongly affected by frame at all ages: Children chose the sure thing more in the positive than the negative frame. Overall, children’s choices and judgements were similar to adults’ in comparable situations. While the judgement data highlight sophisticated abilities, the choice data highlight weaknesses in decision-making.

CHILDREN’S EV JUDGEMENTS FOR LOSS SITUATIONS.

**Multiplication.** This was the first study of children’s EV judgements in loss situations. To think about losses is potentially more demanding than to think about gains (Connolly & Zoelenberg, 2002; Mellers, Schwarz & Ritov, 1999; Lopes, 1987), yet children as young as 5 years used the normative multiplication rule for integrating risk and value, as long as the loss situation was described positively, in terms of what might be saved. This once more confirms children’s early EV competence.

This precocity, as outlined earlier, may be due to EV involving a particularly simple form of multiplication: Probability weights or modifies a value, rather than conjoining with it to form a new dimension as in many physical concepts, a view supported by findings of multiplication in a novel weighting task: Even 4-year-olds know that the content of a message should be weighted multiplicatively by the reliability of its source (Schlottmann & Christoforou, 2005), when the same children use addition in a conjunctive area task. Thus there is now converging evidence for the idea that weighting is simpler than conjunction operations.

Nevertheless, there are also gradations of difficulty within weighting tasks: In the present study, when losses were framed negatively, as losses, 6-year-olds still made multiplicative judgements, but 5-year-olds had difficulties. Their data pattern was irregular, and one may question if it was multiplicative at all, because fanning appeared only when judgements for risky situations were compared to those for sure loss situations. Sure losses, however, may differ qualitatively from risky situations.

When only risky situations were considered, the pattern was largely parallel, with reduced effect of the amount at risk relative to older children and relative to 5-year-olds’ judgements in the save frame. Such parallelism is usually taken to reflect an additive rule. This appears frequently at this age in conjunction tasks and may reflect the operation of a multi-purpose rule, applied when children understand that both informers matter, but not yet how they are related (Anderson & Cuneo, 1978). If 5-year-olds use addition here, it would suggest that their EV concept does not yet include negatively described loss situations.

Even if we consider the 5-year-olds’ pattern a case of irregular multiplication, their grasp of EV for losses would seem fragile and easy to disrupt, perhaps due to the emotions involved. Either way, our results suggest that early understanding of EV is more firmly developed for positive goal achievement. Losses framed positively are
assimilated to this schema by age 5, but an additional year is needed until understanding generalises to losses described as such. It would be interesting to consider the judgements of even younger children, and judgements for gains described positively or negatively, to determine whether the source of the difficulty is the negative formulation or the negative situation.

**Framing Effects.** For older children, frame differences in judgements were minor. In the save frame, judgements were slightly higher than in the loss frame, a “loss aversion”, as also observed with adults (Taylor, 1991; Quattrone & Tversky, 1988). In addition, when we considered the traditional measure of framing, comparing judgements for gambles and sure options of equivalent EV, 6- and 9-year-olds showed consistent signs of weak risk aversion in the save frame. This diminished in the loss frame, and although there was little sign of risk seeking for losses, the preference shift was in the standard direction.

These frame effects were not due to differences in how risk and value were integrated, but stemmed from evaluation processes: Children judged more accurately when all, rather than only some, jellybeans were at risk. In the latter cases they under-weighted the risk factor, leading to flatter curves and slightly elevated judgments for sure losses in the save frame. This resulted in risk aversion in the save frame. Under-weighting of risk also appeared in the loss frame, but in addition children judged risky loss games lower than risky save games, thus diminishing the risk aversion.

Five-year-olds were an exception to this. These children shared the general loss aversion, in fact, this seemed stronger than for older children. Five-year-olds also showed a preference shift in the standard direction, again like older children. In contrast to them, however, 5-year-olds had no clear preference in the save frame, while preferring the gamble in the loss frame.

In this case, the preference shift could be linked to a change from multiplicative to additive integration in the negative frame. However, in the negative frame there also was a reduced effect of the amount at risk and an increased effect of risk, i.e., a change in evaluation, and this in itself would produce risk-seeking. Multiplication and

**Framing Effects in Children**

addition can both lead to risk-seeking or risk-avoidance depending on the values: If risk is under-weighted, it will tend to produce risk aversion, as discussed above. If the amount at risk is under-weighted, in contrast, it will tend to produce risk-seeking. More research is needed to determine whether these weighting effects, and age differences therein, are specific to the present task and sample or appear more widely.

**Fractionation or Compromise Strategy.** EV multiplication here does not involve mental arithmetic, but an intuitive approach, possibly by means of a fractionation strategy (Anderson, 1980; Lopes & Ekberg, 1980): In a first step, the value is located on the response dimension, with adjustment in proportion to the probability in a second step. This account is supported by reaction time data. It can apply to gain and loss situations and may underlie children’s judgements here.

In a related analysis, EV judgement for gambles involves a compromise between the values of alternative outcomes, with the distance between them fractionated in proportion to their probabilities (Schlottmann, 2001). This view leads naturally to risk attitudes, because the compromise can be found in two ways: By downward adjustment from the higher value (keep all/ lose none), or upward adjustment from the lower value (the amount at risk). Risk aversion or risk seeking involve initial focus on the worst or best outcome, respectively, with subsequent under-adjustment. This view fits with Lopes (1987; Schneider & Lopes, 1986) motivational-situational account of individual differences in judgement / decision. In this way, the compromise/fractionation strategy can account for risk attitudes in EV judgements, which in this case depend on situational factors, i.e., framing.

The fractionation strategy also helps understand why sure loss problems and those in which the whole set is at risk might be simpler than others: In sure loss trials, the child performs only the first step of locating the value; risk fractionation is not necessary. Similarly, when the whole set is at risk, the child performs only the second step of risk fractionation, but the value need not be located specifically, for it is simply the 0 point. This may free resources for more accurate evaluation of stimuli.
Thus, when one rather than both steps of the fractionation strategy are required, judgments might be closer to the normative model.

**CHILDREN’S CHOICES.**

*Framing effects and Under-determination of Strategy.* In children’s choices between options of equivalent EV we found a clear standard preference shift from risk aversion in the gain/save frame to risk seeking in the loss frame. This is essentially the adult data pattern, in contrast to Reyna & Ellis (1994), but in agreement with Levin & Hart (2003). The mature data pattern, however, entails a violation of basic decision principles. In prospect theory (Kahneman & Tversky, 1979), framing effects reflect non-normative evaluation, i.e., the s-shaped utility curve. However, other accounts have been proposed (see Levin et al., 1998; Kühberger, 1998).

With children, in particular, it is unclear whether they consider all values and probabilities involved: Apparently risk-seeking and risk-averse choices may occur despite centration on outcomes that ignores risk. If children consider only the best possible gamble outcome (keep all/lose none), this is always better than the sure option it is paired with. Hence children may prefer the gamble, but without attention to risk. Conversely, if children consider only the worst possible gamble outcome (keep none/lose all), this is always worse than the corresponding sure option. Hence they may prefer the sure thing, again without attention to risk. Standard framing occurs if children switch from a worst outcome focus in the positive frame to a best outcome focus in the negative frame.

Centration on probability that ignores outcomes, of course, is possible as well: The probability of losing something is always highest in the sure loss; hence children may prefer the gamble. Conversely, the probability of saving something is highest in the sure save; hence children may prefer the sure option. Thus, probability centration can also produce standard framing. Yet other possibilities are conceivable.

Such suggestions do not just apply to children. In Reyna & Brainerd’s (1991) account, for instance, adult preferences are based on problem gist. This gist is seen as a choice between “a sure something and the possibility of nothing”. In the positive frame, it is better to keep something than nothing (the worst outcome of the gamble), hence the sure thing is preferred. In the negative frame, it is worse to lose something than nothing (the best gamble outcome), hence the gamble is preferred. The point is that no firm conclusions about strategy are possible from a few choice trials. Several underlying strategies, either involving EV integration with non-normative evaluation or various centration strategies, are consistent with standard framing.

This under-determination of strategy when only isolated responses are available for analysis is a problem well known in the developmental literature. In principle, it can be solved through larger response sets that produce different data patterns under different strategies. As illustrated above, Information Integration Theory uses this approach successfully for rule diagnosis in judgement. Siegler’s (1981) Rule Assessment methodology is a well-known application of the same idea to children’s choices, but it cannot diagnose strategies reliably, due to restrictive assumptions about evaluation (Wilkening, 1988; Wilkening & Anderson, 1983; 1991). Thus the value of choice tasks for investigation of children’s strategy is limited.

*Risk Effects on Choices.* One aspect of the results at least helps us constrain children’s strategy on the choice trials: In both Experiments 1 and 2 we found effects of varying EV/risk level across scenarios. These effects were largely independent of frame. This provides some evidence that children did not completely centre on outcomes and ignore risk in their choices.

It is unclear, however, how risk affects children’s choices, because in Study 1 they chose the sure thing more often when the risk in the gamble was high, whereas the opposite appeared in Study 2. Normatively, of course, risk level should not matter. Nevertheless, Kühberger et al. (1999) provided a rationale for both findings: If probability affects choice in an unmediated way, then the higher the probability of winning in the gamble (i.e., the lower the risk), the more attractive it should appear, and the higher the risk of losing, the more unattractive it should appear. Therefore one would expect more sure thing choices with higher risk -- a pattern as in Experiment 1.
The opposite prediction, however, follows from consideration that if the risk changes, then -- in order to maintain equivalent EV for both options -- the sure outcome changes too. Thus, the higher the probability of winning in the gamble (the lower the risk), the smaller the difference between the sure and risky gain, in which case one might as well avoid the risk. In the negative frame, the higher the risk of losing, the smaller the difference between the risky and sure loss, thus one might as well take the risk. Under this rationale, more gamble choices are expected with higher risk. This appeared in Experiment 2, and it was also the pattern with more support in a meta-analysis of adult studies (Kühberger et al., 1998).

Why children switch from one to the other pattern across experiments is unclear. It could be due to the change from gain to save frame in Experiment 2 (but this does not explain why the risk effect reverses in the loss frame -- equivalent in both studies), or to concomitant changes in stimulus display, or it could be due to differences in experience between the two samples -- children in Experiment 1, but not 2, had participated in a previous EV study. Further work on this is necessary. Both experiments, at any rate, were consistent in the main result: Children as young as 6 years show a standard framing pattern in their choices, as also appears with adults.

THE RELATION BETWEEN JUDGEMENT AND CHOICE.

Experiment 2 involved judgement and choice for the same children. We cannot compare the underlying strategies empirically, because, as already discussed, the choice strategy is under-determined. However, we can compare framing effects, and while these showed the same qualitative trends in both tasks, they were much stronger in choice. Moreover, judgement predicted choice only on half of the trials or less. This suggests that children’s strategies in the two tasks were not closely related.

The conclusion fits with previous empirical comparison of judgement and choice. With adults, Mellers, Chang, Birnbaum & Ordóñez (1992) found different strategies for different forms of decision preference task. With children, comparisons in other domains using Information Integration and Rule Assessment (Wilkening & Anderson, 1991) found that judgement strategies are often in advance of choice strategies. This might be because Rule Assessment can misdiagnose children’s approach or because strategies are highly task-specific, even within the same experimental session.

Regarding the latter possibility, dimension-by-dimension comparison has been suggested for choice, with one-dimensional centration rules at young ages (Siegler, 1981). This could be in response to the complex comparative structure of stimulus displays. Comparison is not needed in typical judgement tasks, which display only a single stimulus, and this in turn may allow for more complex 2-dimensional integration at younger ages. A few studies have used judgement-adjustment tasks involving comparison, such that two stimuli have to be equalised (Falk & Wilkening, 1998; Levin, Wilkening & Dembo, 1984; Wilkening & Anderson, 1991). These studies have tended to find more one-dimensional rules or even un-systematic responding than usual in children’s judgement, consistent with a view that stimulus structure, not response mode per se affects level of processing. Developmentalists often prefer choice to judgement because response requirements are less. However, the concomitant increase in stimulus complexity may have effects on processing that make choice tasks unsuitable measures of children’s competence.

Accordingly, even though children judge EV multiplicatively, their choice strategy may be simpler, perhaps involving centration on a single dimension. Frame effects in evaluation could be similar despite such differences in integration, but to the extent that choices depend on a single factor, frame effects might be stronger in choice than judgement where they are mitigated by the other factor. Alternatively, of course, children might simply evaluate the options differently in the two tasks.

Intuitive and Analytic Cognition. The present task differences may also be described as judgement involving more intuitive cognition, while choice involves more analytic cognition. The latter is characterised as formal computation or explicit calculation that may be verbalised, while intuition is approximate, with perception-like, less articulated processing (Brunswik, 1956; Haines, 1996). Simple judgement tasks, as used here, are seen as intuitive because they require estimation rather than
calculation, eliciting more synthetic, integrative processes. The comparative structure of choice tasks, in contrast, leads to analytic dimension-by-dimension approaches.

This does not mean that intuitive processing is undifferentiated and irrational. Our results show that intuition, just like perception, is highly structured and captures important features of normativity. At the level of subjective experience, however, we may be able to report only the output, not the underlying process, a vague feeling, not a rationale. This view is consistent with findings that children’s verbalisations in choice tasks tend to fit with Rule Assessment (Siegler, 1981). Verbalisation has not been much studied in Information Integration tasks, perhaps because such data appear uninformative to researchers. In the author’s experience, at any rate, neither children nor adults can usually articulate the rules underlying their intuitive judgements.

Dual-systems theories also appear in the adult literature. Stanovich & West (2000), for instance, distinguish System 1, automatic, heuristic, implicit processing from System 2, analytic, controlled, explicit processing. Biases, such as framing effects, are ascribed to system 1, in apparent conflict with the view above. The contradiction may not be serious, however, if differences between intuitive and analytic processing are not seen as categorical, but a matter of degree. Choice tasks as used here may involve a more analytic form of cognition than judgement tasks, yet need not involve full-fledged calculation – in Siegler’s (1981) data, only some adults employ calculation in some problems not solvable in simpler ways. Similarly, judgement tasks are intuitive if they require estimation, but can be made more analytical by introducing a need for calculation (Falk & Wilkening, 1998). In general, different tasks may engage both systems to varying extent.

Moore and colleagues (Surber & Haines, 1987; Moore, Dixon & Haines, 1991; Ahl, Moore & Dixon, 1992; Dixon & Moore, 1996,1997; Haines, Dixon, & Moore, 1996) have studied differences between analytical and intuitive strategies in tasks with clear-cut contrasts between the two. More research is needed, however, to understand the interplay of intuitive and analytic cognition in tasks involving both, as well as their relation in development (Schlottmann, 2001). In any event, results such as found here, show clearly that tasks engaging intuitive processes give a more positive view of children’s competence than the choice tasks used since Piaget & Inhelder (1975).

CONCLUSION.

Children’s EV concept is not a unitary, all-or-none affair (Anderson, 1991; Falk & Wilkening, 1998): Different states are elicited in judgement and choice, seen, for instance, in more or less pronounced framing effects. Different states are also elicited by positive and negative probabilistic goals: Young children take longer to learn how to cope with situations framed in terms of negative rather than positive consequences. Nevertheless, they achieve this prior to instruction with probabilities in school: Even 5-year-olds can judge EV of risky situations involving potential losses. Children thus learn about EV in the course of everyday experience or – given that even foraging bees are sensitive to utility and risk (e.g., Real, 1991) – there could be a biological predisposition. Be this as it may, young children first access EV not as an abstract mathematical concept, but as an intuitive notion basic to understanding goal directed action in an uncertain world (Fischbein, 1975; Anderson, 1991; Schlottmann, 2001).
ACKNOWLEDGEMENTS

Many thanks are due to the children and staff at the CoE Primary School in Bromley, Kent, at St Aloysius Primary and Trevor-Roberts Infant School in London, and to Sarah Manktelow and Lucie Spooner for testing some of the children. A preliminary report of some of these data was given at SRCD 2003, Washington, DC, and at the 16. Tagung der Fachgruppe Entwicklungspsychologie der Deutschen Gesellschaft für Psychologie, Mainz, Germany, 2003.

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