A comparison of children and adults' judgements and decisions based on verbal uncertainty statements

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Abstract

Children distinguish less well than adolescents the *numerical meaning* conveyed by verbal probabilities (e.g., Mullet & Rivet, 1991). Little is known, however, about children's ability to grasp the *directionality* of verbal probabilities (Teigen & Brun, 1995). We expected children to only be influenced by directionality and congruence of statement framing with their goal. Thirty children and 29 adults made probability judgements and decisions in a treasure hunt context. Results revealed that children are sensitive to the numerical meaning of verbal probabilities in decisions, and also in probability judgements related to goal-incongruent statement framings. The different demands implied by judging probabilities and decision-making will be discussed, as well as the independence of directionality and numerical value in adults' interpretation of verbal probabilities.

Keywords: verbal uncertainty; probability judgement; decision making; directionality.

Imagine that an 8 year-old boy wants to invite a friend to go to the park with him during the week-end. Before inviting him he asks his parents whether it will rain. Should they answer (1) or (2)?

(1) There is a 20% chance that it would rain.

(2) There is a little chance that it would rain.

According to preference paradox (e.g., Erev & Cohen, 1990), they will probably prefer to use the verbal probability (*There is a little chance*) to communicate uncertainty. Furthermore an 8 year-old child has not been taught about numerical probabilities (percentages and frequencies). Corpora of French language used in primary school handbooks (Lété, Sprenger-Charolles & Colé, 2004) revealed that children are confronted with uncertainty words as early as first grade: for example, *possible* occurs as often as *neighbor* in first grade handbooks. Yet to our knowledge very few studies investigated verbal probabilities comprehension in childhood (but, for an exception, see Mullet & Rivet, 1991; Watson & Moritz, 2003).

Besides understanding what the parents mean by *There is a little chance*, the boy will also have to decide if he should invite his friend to go to the park on the basis of this statement. In fact children, like adults, have to make decisions on a daily basis. To do so they can rely either on experience or on information that is communicated to them. Since adults are more likely to communicate uncertainty to children using verbal probabilities, the study of children's decision-making activities would also benefit from knowledge of how they understand verbal probabilities and make decisions on their basis. Finally, verbal probabilities are not used in isolation but inserted in general statements of uncertainty. Their interpretation can therefore depend on the different pieces of information carried by context (e.g., Weber & Hilton, 1990). The study we report here aims to bring a new look on comprehension of verbal probabilities and on their use in decision-making, in childhood and adulthood. Specifically it will examine how children and adults take into account the multidimensionality of this type of uncertainty expressions when making decisions.

Verbal probabilities express a degree of certainty, possibility or obligation of an event by a modal adjective (e.g., *likely*, *uncertain*) or a verb (e.g., *may*). They are embedded in utterances expressing the probability of an event as in *It is likely that* x *will occur*. This modal term can be combined with a modifier (e.g., *few*, *strongly*) which will increase or decrease the degree of certainty expressed by the verbal probability, as in *It is highly likely that* x *is true*. Thus, the first dimension of verbal probabilities is the numerical value defining, albeit vaguely, the chances to see an event occur or be true.

Early work on verbal probabilities examined how they translated into numerical probabilities (e.g., Mosteller, & Youtz, 1990). This line of work developed in the characterization of their distribution of probabilistic meaning (e.g., Wallsten, Budescu, Rapoport, Zwick, & Forsyth, 1986). More recently, a new line of work was initiated with the introduction of the concept of *directionality* (Teigen & Brun, 1995). The directionality of a probability expression is dichotomous (i.e., it's either positive or negative) and focuses the listener's attention on the occurrence or truth of the event (if positive) or on its non-occurrence or falsehood (if negative).

Through focusing, directionality leads to framing effects in decisions based on verbal probabilities (Teigen & Brun, 1999): for the same estimated numerical probability and the same positive event (e.g., a 30-35 % chance that a headache treatment will be helpful), a positive probability expression (e.g., *There is some possibility*) leads participants to decide more often to act (e.g., follow the treatment) than a negative one (e.g., *It is quite uncertain*). Thereby the directionality concept has defined what we will call the *semantic-pragmatic* dimension of verbal probabilities.

Teigen and Brun's (1999) results show that using verbal expressions to communicate uncertainty not only tells about a degree of uncertainty, but also about what is preponderant in the speaker's mind, that is whether his attention is directed to the occurrence or non-occurrence of the outcome. Therefore, a verbal probability conveys both information about numerical level of probabilities and information about directionality.

As evoked earlier, verbal probabilities are inserted in utterances: they always communicate uncertainty *about* an uncertain event. As such, the communication of uncertainty can be framed in different ways (Villejoubert, Almond, & Alison, 2009). In claim or *statement framing*, the same uncertain event (i.e., with a given probability of occurrence) can be described in a positive frame congruent with listeners' goals (e.g., *There is a good chance that you will pass your exam*) or in a negative frame, namely a frame that is incongruent with their goals (e.g., *It is unlikely that you will fail your exam*).

We therefore propose to study the interpretation of verbal probabilities in a wider context and examine the impact of statement framing. Thus, the first aim of the present study will be examine the effect of three dimensions on individuals' probability judgements and decisions: the numerical value conveyed by the verbal probability (low vs. high), its directionality (positive vs. negative), and the statement framing (congruent vs. incongruent with the listener's goal).

To our knowledge no study has yet investigated systematically these three dimensions on both likelihood judgements and decision-making, in adulthood and in childhood. Although past research has examined simple interactions of these variables. Teigen and Brun (1999) found that the numerical value modulates the directionality effect: both positive and negative verbal probabilities lead more often to a positive behavioral prediction when the numerical value is high rather than low. The numerical value can itself be modulated by the event value: a positive verbal probability is interpreted as having a lower numerical value if it announces a severe event than if it announces a mild one (e.g., Bonnefon & Villejoubert, 2006). Finally, Villejoubert et al. (2009) showed that probability words chosen to express the numerical uncertainty of a statement conveyed higher levels of uncertainty when it was inferred from a positively framed statement (e.g., there is a 70% probability that X is true) rather than from a negatively framed one (e.g., there is a 30% probability that X is not true). To our knowledge, however, the potential interaction between directionality and statement framing has not been investigated yet.

Very few studies investigated verbal probabilities comprehension in childhood (Mullet & Rivet, 1991; Watson & Moritz, 2003). Furthermore these studies did not take into account the concept of directionality. However these two studies found that children distinguish less well the different levels of numerical value carried by verbal probabilities compared to adolescents. Mullet and Rivet (1991) manipulated statement framing (pass vs. fail) and showed that the frame interacts with the numerical dimension of verbal probabilities. In fact children could integrate the statement framing when evaluating uncertainty and reverse their estimates accordingly. However the authors' design did not distinguish between the directionality and the numerical value, so it is possible that directionality also independently interacts with the event value and/or numerical value. Finally, an insight about how children process directionality can be found in modifier studies. Indeed, according to Moxey and Sanford (2000), directionality can be considered as an argumentative function of language (e.g., Anscombre & Ducrot, 1983). Champaud and Bassano (1987) observed a sensitivity of 6-years-old to the argumentative function of some modifiers (especially negative ones). Thus it is plausible to assume that children will be sensitive to the directionality of verbal probabilities although this assumption remains to be empirically verified.

To sum up, whereas previous studies found adults were sensitive to each dimension of uncertainty expressions and that each of these dimensions may interact independently with one another, children studies found a sensitivity to the numerical value and the statement framing but did not test whether children would be sensitive to the directionality of verbal probabilities. All together these results suggest that when judging uncertainty expressions and making decision on their basis, adults should use the directionality, the numerical value and the statement framing, while children should be sensitive to framing and may also be sensitive to directionality but should have more difficulties in differentiating between different levels of numerical meaning.

Method

Participants

Fifty-nine people took part in this study. Twenty-nine of these participants (26 women and 3 men) were studying different subjects in the University of Toulouse and volunteered to participate (mean age = 22.6 years, SD = 3.5). The remaining participants were children (13 girls and 17 boys) enrolled in the French third grade in a primary school near Toulouse (mean age= 8.7 years, SD = 0.3); consent was sought from both their parents and the children themselves. Participants were not paid and did not receive incentives to participate. The experiment was conducted in French and they were all French native speakers.

Material and procedure

Probability expressions were manipulated in a 2×2×2 within-subjects design. Eight probability expressions were used, corresponding to the eight combinations (see Table 1) of the levels of directionality (positive vs. negative), numerical value (low vs. high), and statement framing (congruent vs. incongruent with the task goal). Modal terms used in these expressions were chosen according to their frequencies in French primary school handbooks (Lété, Sprenger-Charolles & Colé, 2004); final choices were made in reference to previous studies (Honda & Yamagishi, 2006; Juanchich, 2007), so that the numerical value could be assumed to be equivalent within each pair of the different combinations between the directionality and the statement framing factors. Age was a between-subject factor and the experiment was based on a 2×2×2×2 mixed-design.

We used a treasure hunt scenario to implement this design. First, participants read the following introductory text (translated from French):

> "Here is a treasure island. On this island there are not only one but several chests. In some chests, there is part of the treasure: each one of these chests is filled with the same amount of treasure. In the other chests, there is no treasure but a trap: if you open these trap chests, all the chests will be locked and you will not be able to take the treasure. Fortunately hints are available to help you find the good chests. For each chest you thus will have to read the hint and to say if you think that the chest contains part of the treasure. You will also have to say what you would really do if the chest were in front of you. Do not forget that you should open only the chests filled with a treasure if you want to win the treasure."

The "hints" corresponded to the eight probability expressions mentioned earlier. Each hint was judged two times, to assess both probability judgements and decision-making on the basis of probability expressions. Thus the first question (*Do you think that the chest contain the treasure?*) assessed the probability judgement on a non-labeled 11-point scale; the second one (*What would you do if the chest was in front of you right now?*) assessed the decision-making under uncertainty using a choice task since deciding to open the chest being considered a choice leading to an uncertain and possibly risky outcome. The order of the two questions was not counterbalanced following Schlottmann and Tring (2005).

To make sure that participants were familiarized with the task and combinations of factors, we made them first practice in a familiarization phase. This phase and the experimental one used exactly the same items: four anchoring items were given first in the two phases and then the eight experimental items were given in different pseudo-random orders for each phase. In addition, the familiarization phase allowed participants to go back to change their responses, contrary to the experimental one. However, no feedback about the performance was given to participants after the familiarization. Participants were tested individually.

Results

Probability judgement

Means for each combination of the four factors are given in Table 2. A 2×2×2×2 mixed ANOVA revealed a main effect of framing ($F(1,55) = 12.93$, $p < .01$, $\eta^2_p = .19$), and no main effect of the directionality ($F(1,55) = 1.82$, ns), numerical value ($F(1,55) = 1.73$, ns) or age ($F(1,55) = 1.48$, ns). A reliable two-way interaction was observed between the statement framing and the directionality ($F(1,55) = 32.53$, $p < .001$, $\eta^2_p = .37$), between the statement framing and the numerical value ($F(1,55) = 43.3$, $p < .001$, $\eta^2_p = .44$), and between the statement framing and the age ($F(1,55) = 11.69$, $p < .01$, $\eta^2_p = .18$).

A reliable three-way interaction was also observed between the statement framing, the numerical value and the age ($F(1,55) = 14.9$, $p < .001$, $\eta^2_p = .21$).

More local analyses were conducted within each combination of age and statement framing, using 2×2 repeated ANOVA. Results showed that when the statement framing was congruent with the task goal, adults judged the likelihood of reaching the task goal (finding the treasure) as higher if expressed by a positive verbal probability than if expressed by a negative one ($F(1,26) = 20.62$, $p < .001$, $\eta^2_p = .44$). Also they judged this likelihood as higher when the numerical value was high than when it was low ($F(1,26) = 51.93$, $p < .001$, $\eta^2_p = .67$).

Children on the other hand judged this likelihood significantly higher when the verbal probability was positive than when it was negative ($F(1,29) = 32.91$, $p < .001$, $\eta^2_p = .53$). No reliable effect of the numerical value was observed in children ($F(1,29) = 1.75$, ns).

Table 1: probability expressions (translated from French) combining the different levels of directionality, numerical value (NV) and statement framing

directionality	statement framing	low NV	high NV	
positive	congruent	There is a little chance…	It is very possible…	…that the treasure is in the chest
	incongruent	There is a little possibility…	It is almost sure…	…that the treasure is not in the chest
negative	congruent	It is very little certainty…	It is not absolutely sure…	…that the treasure is in the chest
	incongruent	It is almost impossible	It is not very certain…	…that the treasure is not in the chest

Table 2: mean probability judgements (SD) according to the directionality (dir), the numerical value (NV), the statement framing (event) and the age

	dir	event	low NV	high NV
children	positive	congruent	69.83 (23.87)	75.33 (23.56)
		incongruent	46.33 (27.98)	31 (24.08)
	negative	congruent	55.5 (27.33)	54.83 (28.63)
		incongruent	52.33 (32.56)	44.67 (23.96)
adults	positive	congruent	44.81 (17.95)	71.3 (19.59)
		incongruent	58.7 (20.69)	28.89 (24.51)
	negative	congruent	29.26 (20.97)	57.41 (18.78)
		incongruent	67.78 (22.63)	45.37 (19.8)

When the statement framing was incongruent with the task goal, adults judged the likelihood of reaching the task goal as lower if expressed by a positive verbal probability than if expressed by a negative one ($F(1,28) = 7.76$, $p < .01$, $\eta^2_p = .28$). They also judged it as lower when the numerical value was low than when it was high ($F(1,28) = 41.18$, $p < .001$, $\eta^2_p = .6$).

Children in this case judged this likelihood significantly lower when the numerical value was high than when it was low ($F(1,29) = 7.77$, $p < .01$, $\eta^2_p = .21$). No reliable effect of the directionality was observed this time ($F(1,29) = 3.78$, ns).

No reliable interaction had been observed between the directionality and the numerical value, regardless of the event value and of the age group.

Decision making

Proportions of risky choices (for opening the chest) for each combination of the four factors are given in Table 3. The main and combined effects of the four factors on these proportions were tested by a Wald chi-square.

The Wald chi-square test revealed no reliable effect of the statement framing ($\chi^2_W(1) = 1.27$, ns), of the directionality ($\chi^2_W(1) = 2.37$, ns), of the numerical value ($\chi^2_W(1) = 1.03$, ns), or of the age ($\chi^2_W(1) < 1$, ns).
A reliable two-way interaction was observed between the statement framing and the directionality ($\chi^2_W(1) = 40.79$, $p < .001$), between the statement framing and the numerical value ($\chi^2_W(1) = 34.25$, $p < .001$), and between the statement framing and the age ($\chi^2_W(1) = 6.96$, $p < .01$). A reliable three-way interaction was also observed between the statement framing, the numerical value and the directionality ($\chi^2_W(1) = 5.17$, $p < .05$).

More local analyses were conducted within each combination of age and event value. When the statement framing was congruent with the task goal, both adults and children took a risky decision more often if the verbal probability was positive than if it was negative ($\chi^2_W(1) = 16.37$, $p < .001$ and $\chi^2_W(1) = 19.56$, $p < .001$

Table 3: proportions of risky decisions (open the chest), as function of the directionality (dir), the numerical value (NV), the statement framing (event) and the age

	dir	event	low NV	high NV
children	positive	congruent	.58	.93
		incongruent	.37	.13
	negative	congruent	.20	.51
		incongruent	.58	.51
adults	positive	congruent	.34	.82
		incongruent	.65	.13
	negative	congruent	.13	.37
		incongruent	.70	.55

respectively). They also both took more often a risky decision when the numerical value was high than when it was low ($\chi^2_W(1) = 14.19$, $p < .001$ and $\chi^2_W(1) = 18.52$, $p < .001$ respectively).

When the statement framing was incongruent with the goal task, both adults and children took more often a risky decision when the verbal probability was negative than when it was positive ($\chi^2_W(1) = 12.03$, $p < .01$ and $\chi^2_W(1) = 10.76$, $p < .01$ respectively). They also both took more often a risky decision when the numerical value was low than when it was high ($\chi^2_W(1) = 11.87$, $p < .01$ and $\chi^2_W(1) = 6.92$, $p < .01$ respectively).

No reliable interaction had been observed between the directionality and the numerical value, regardless of the event value and of the age group.

Discussion

This study aimed to investigate probability judgement and decision-making under verbal uncertainty in childhood and adulthood. We expected adults to take into account the three dimensions of uncertainty expressions (directionality, numerical value, statement framing) whereas we expected children to take into account only the directionality and the statement framing.

In accordance with this hypothesis, our results revealed that both children and adults take into account the statement framing in their judgement and decision-making: patterns of responses observed when the statement was congruent with the task goal were reversed when it was not congruent with it. While our results indicated that adults systematically took the directionality into account, both in judgement and decision-making, they are conform less to our expectations in childhood: children took it systematically into account in decision-making, but in judgement they only considered it when the statement framing was congruent. Finally where we expected some age-differences, we found also an unclear pattern: adults always took into account the numerical value, in judgement and decision-making, which we expected; but children also took it systematically into account in decision-making, neglecting it in judgement only in the case of a positive event.

Thus we can consider that children take into account the numerical value of verbal probabilities most of the time, which is surprising regarding the previous studies of verbal probabilities' comprehension by children (Mullet & Rivet, 1991; Watson & Moritz, 2003). However we highlighted that these studies did not consider the directionality in their analyses, so that their results could be due to a confound variable. Once the directionality is considered as another variable, it seems that children, as adults, are sensitive to the numerical value.

Another main difference with the previous studies may explain our unexpected results. Whereas we investigated both judgement and decision-making, the previous studies only observed the probability judgement. And while children in our study take systematically into account the numerical value when making decision, when judging probability they considered it only in case of incongruent statement framings. If judging probabilities remains only an evaluation process, making decisions carries more consequences. Specifically in our study making one unique bad choice would make people lose the entire game whereas missing one good choice would only reduce the scale of the outcome. This prospective could have prompted children to be more accurate in their choices. Moreover this could also explain why they were sensitive to the numerical value even in judging expressions with an incongruent statement framing: the announced negative outcome would then have raised their awareness of the consequences, their judgement being therefore contaminated by their anticipation of what they should do.

This explanation is consistent with some recent developments in probabilistic abilities studies. Starting with Piaget and Inhelder (1951), who stated that children cannot use probabilities until 7 years old, becoming really efficient after 10 years old, it had long been considered that children were unable to reason in probabilistic terms. But although some authors confirmed children's difficulties to differentiate between certitude and possibility until early adolescence (e.g., Fischbein, Nello, & Marino, 1991), others showed (e.g., Girotto & Gonzalez, 2008) that children can use probabilities to make decisions. So children seem able to take probabilities into account to do daily tasks even if they are not able to reason formally about them. As we evoked above, this could be because they become aware of consequences when it comes to decisions. It could be also -and it could also be the case in our study- due to some difficulties expressing their judgement in the format task, even if this judgement is accurate enough to make appropriate decisions. Here we have to remember that children are not taught about probabilities before the very end of primary school. Hence their representation of probabilities has not been shaped yet according to formal rules.

A methodological explanation, however, remains to be discussed. We decided not to counterbalance the two tasks in reference to previous studies (Schlottmann & Tring, 2005). However, because we observed age-differences in the first task but not in the second one, the issue of a potential order effect has to be considered. Nevertheless if the apparition of an effect of the numerical value was due to some familiarization with the material, we would expect the numerical value to have had first an effect with the congruent statement framing cases because they were affirmative. Indeed negation is considered as more costly to process (see Kaup 2006, for a review), therefore we can assume that it is treated with more difficulty by children. Furthermore such a familiarization effect should have appeared only in the second task, given that combinations of directionality, numerical value and statement framing was given pseudo-randomly: if a familiarization with the material occurred during the judgement task, making children more accurate at the end of it, this could not be observable by a specific pattern such as the one we found.

The adults' results, expected by our hypothesis, are also interesting in the context of verbal probabilities' theories. Whereas the semantic-pragmatic view considers the directionality as important a feature as the numerical value, what we will call the formalist view considers that the directionality is a feature only depending on the numerical value (Budescu, Karelitz & Wallsten, 2003). Thus according to this view positive verbal probabilities express only high levels of probability, and negative ones only low levels. By asking people to judge what we thought to be incongruent verbal probabilities (positive ones carrying a low numerical value and negative ones carrying a high numerical value), we found that adults can judge some positive verbal probabilities as meaning a low level of probability, and some negative ones as meaning a high level of probability. Thus directionality appears to us as an independent feature of verbal probabilities.

Such a claim could be confirmed by adding pragmatic variables to the interpretation of verbal probabilities. According to the Relevance Principle (Sperber & Wilson, 1986), the directionality could be interpreted as a deliberated choice of the speaker, indicating that there has to be a reason why he chose this directionality rather than the other. Thus a benevolent speaker, who should be considered as willing to help the listener, should prompt a response driven by the directionality. Conversely a malevolent speaker, who should be considered as willing to trick the listener, should prompt a response driven by the numerical value. Another distinction between epistemic and physical uncertainty (e.g., Robinson, Rowley, Beck, Carroll & Apperly, 2006) in this same paradigm should prompt more reliance on the directionality when the uncertainty is epistemic (i.e. when the listener is the only one to not know the outcome) than when it is physical (i.e. nobody knows the outcome). Such results would demonstrate the pragmatic dimension of the directionality.

Finally further developmental investigation will have to be conducted to understand the factors which will help taking into account the numerical value systematically. Younger children in this perspective should only show sensitivity to the directionality, whereas older children should start to use the numerical value in every case. Especially once taught formally about probabilities, they should become able to express their probability judgements in a way similar to adults.

As already observed with probabilities themselves, children can make rational choices based on verbal probabilities, though they cannot express judgements in a formal way. Adults, while making rational choices and expressing formal judgements, showed patterns sustaining the semantic-pragmatic view and the independence of the directionality regarding the numerical value of verbal probabilities.

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