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Can membership-functions capture the directionality of verbal probabilities?

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Verbal probabilities are a common mean for communicating risk and uncertainties in many decision-making settings (e.g., finance, medicine, military). They are considered directional because they elicit a focus on either the outcome occurrence (e.g., there is a chance) or on its non-occurrence (e.g., it is unlikely). According to a quantitative perspective, directionality is dependent on the vague probabilistic meaning conveyed by verbal probabilities—e.g., p(outcome) $> .50 = >$ focus on outcome occurrence. In contrast a more qualitative perspective suggests that directionality depends on contextual factors. The present study tested whether the directionality of verbal probabilities was determined by their vague probabilistic meaning, by contextually manipulated variables (i.e., representativeness and base rate), or by a combination of both. Participants provided their own expressions to describe the guilt of a suspect and then assessed the vague probabilistic meaning and directionality associated with those expressions. Results showed that directionality was mainly determined by the vague probabilistic meaning but also by the base rate of guilt. Although attention focus on the occurrence or the non-occurrence of the target outcome is dependent on vague probabilistic meaning, it cannot be fully accounted for by it.

Keywords: Uncertainty; Verbal probability; Directionality; Membership-function.

Verbal probabilities are linguistic terms used to quantify risk or uncertainty, such as "there is a chance" or "it is uncertain". Verbal probabilities are the most common and preferred means to communicate doubts and uncertainty.

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People are more likely to make predictions with verbal probabilities than precise numerical ones in casual contexts (Wallsten, Budescu, Zwick, & Kemp, 1993) as well as in professional contexts (e.g., in medicine, Brun & Teigen, 1988; Neuner-Jehle, Senn, Wegwarth, Rosemann, & Steurer, 2011; in financial analysis, Piercey, 2009; in military intelligence, Weiss, 2007). Therefore, in many situations where one is asking information about an uncertain outcome, this advice is likely to be formulated with a verbal probability and the decision of the advice-taker to be influenced by its properties (Teigen & Brun, 1999). Furthermore, because verbal probabilities are considered a natural format of risk communication, their use is recommended for communicating risks by experts and political organisations, such as the European commission on drugs (European Commission, 1998) and the Intergovernmental Panel on Climate Change (IPCC, 2007). Yet we remain unsure about the properties of those expressions and researchers call for further research on verbal probabilities necessary to tailor effective risk communication strategies (e.g., Juanchich, Sirota, & Butler, 2012; Patt & Suraje, 2005; Sirota & Juanchich, 2012). The present paper aims to respond to this call by investigating whether the effect of verbal probabilities on attention orientation is determined by their vague probabilistic meaning, by the context in which the expression is given (i.e., base rate and representativeness of the outcome), or by both these dimensions.

HOW VERBAL PROBABILITIES DIRECT ATTENTION

When facing an uncertain outcome (e.g., it is possible that it will rain), we can either focus on its occurrence (e.g., rain) or on its non-occurrence (e.g., no rain), which will in turn determine decision making (e.g., taking an umbrella; Teigen & Brun, 1999). Verbal probabilities have a *directionality* that directs the listener's attention towards either the target outcome occurrence or its non-occurrence (Honda & Yamagishi, 2006; Juanchich, Teigen, & Villejoubert, 2010; Teigen, 1988; Teigen & Brun, 1995). Positive expressions (e.g., it is possible, it is likely) focus the attention of the listener on the occurrence of the target outcome by increasing the mental availability of reasons supporting its occurrence, whereas negative expressions (e.g., it is not unlikely, it is not certain) focus the attention on the outcome non-occurrence by increasing the availability of reasons against its occurrence (Teigen & Brun, 1995). The fact that verbal probabilities affect attention orientation towards different future states of the world (outcome occurrence vs non-occurrence) is generally agreed upon, but whether this directionality is a special feature of verbal probabilities on its own or whether it is a mere consequence of the vague probabilistic meaning they convey remains a source of controversy.

There exist two approaches to verbal probabilities, accounting differently for the effect of verbal probabilities on the recipient's attention. One approach suggests that directionality stems from the vague probabilistic

meaning conveyed by verbal probabilities. The probabilistic meaning of verbal probabilities is the degree of certainty that those quantifiers is conveying. For example, ''It is possible'' conveys a medium probability of around 50% (Juanchich et al., 2012). The probabilistic meaning of verbal probabilities is considered as vague because of its large between- and within-participant variability (Budescu & Wallsten, 1995). The vague probabilistic meaning is often represented by a fuzzy membership-function with a probability scale as X axis (0–100%) and a Y axis ranging from 1 (for numerical probabilities that are not conveyed by a given verbal probability) to 10 (for probabilities that are perfect exemplars of the verbal probability; Wallsten, Budescu, Rapoport, Zwick, & Forsyth, 1986; see Figure 1). Accordingly, directionality is defined by the peak and skew of the membership function of a given verbal probability: positive phrases are assumed to have peaks above 50% and be negatively skewed (i.e., to be more representative of higher numerical probability values) and, conversely, negative phrases are assumed to peak below 50% and be positively skewed (i.e., to be more representative of lower numerical probability values; Budescu, Karelitz & Wallsten, 2003). The other approach suggests that directionality does not stem from vague probabilistic meaning but is chosen based on contextual cues such as outcome or attribute framing (Teigen & Brun, 2003b; Villejoubert, Almond, & Alison, 2009) or speakers' communicative intentions (Juanchich et al., 2010). Previous findings, however, fall short of providing convincing evidence to support either of these assumptions. The present research tests whether directionality can be fully accounted for by vague probabilistic meaning, by contextual cues or by a combination of both.

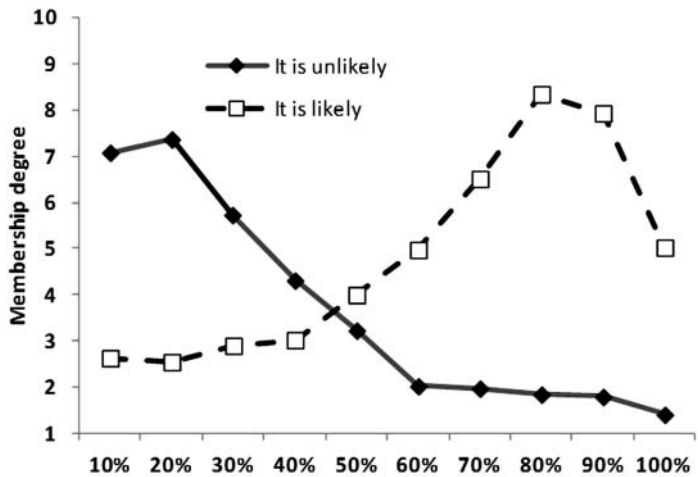

Figure 1. Examples of mean membership-functions for two verbal probabilities.

VERBAL PROBABILITIES HAVE A SINGLE FEATURE: THEIR VAGUE PROBABILISTIC MEANING

Verbal probabilities are said to convey vague probabilistic meanings because, when asked to translate a verbal probability into a numerical one, different individuals provide different numbers, and because even the same individual might provide different estimates at different occasions (Clark, 1990). This inter- and intra-individual variability is robust and occurs with or without specific context (Beyth-Marom, 1982; Brun & Teigen, 1988). Yet this vague probabilistic meaning usually covers either the first half of the probability scale (e.g., it is unlikely), its medium point (e.g., it is possible), or its highest half (e.g., it is likely) with good consistency across studies (Teigen & Brun, 2003).

According to Budescu and Wallsten (1995, p. 287) the vague probabilistic meaning conveyed by verbal probabilities could capture directionality as it can "capture subjective meanings and interpretations in a manner that allows prediction of independent behavior". Indeed, it is reasonable to assume that outcomes that have a high probability of occurring direct attention towards the outcome occurrence, whereas outcomes that have a low probability direct attention towards the outcome non-occurrence. The vague probabilistic meaning conveyed by probability phrases can be determined by the construction of membership-functions that represent their vague probabilistic meaning on a probabilistic scale. Membership-functions can be obtained with the Multiple-Stimuli-Method (MSM; Budescu et al., 2003; Wallsten et al., 1986). In this method participants judge to what extent a verbal probability communicates the probability values ranging from 0% to 100% in increments of 10%. The MSM results in a function representing the degree of membership (Y axis) of each probability value (X axis) in the verbal probability (see Figure 1 for an example). The main interest of membership-functions is that they capture all the probabilistic meanings an expression can undertake and thus are context independent. For example, "likely" has the same function whether it qualifies a side effect or a prospective salary (Budescu et al., 2003). Membership-functions are characterised by their peak, which represents the best probability communicated by the expression, and by their skew, which represents the symmetry of the probabilistic meaning around the peak. For example, the membership-function of "likely" shown in Figure 1 indicates a peak located at 80% and a negative skew (a greater membership area on the left of the peak than on the right), whereas unlikely has a peak located at 20% and is positively skewed (a greater membership area on the right of the peak than on the left). All the area below the function represents the potential probabilistic meanings that a verbal probability can undertake.

Budescu et al. (2003) showed that directionality was determined by membership-functions parameters. Membership-functions of positive verbal

probabilities had a peak above 0.50 and a negative skew, whereas negative verbal probabilities had a peak below 0.50 and a positive skew. Consistent with the view that directionality depends on vague probabilistic meaning, Smithson, Budescu, Broomell, and Por (2012) showed that the negative and positive verbal probabilities used in the IPCC report yielded different dispersions of minimal, best, and maximal estimates (negative terms had a greater dispersion). However, the sample of verbal probabilities used by Budescu et al. and by Smithson et al. did not include critical test phrases for which directionality and degrees of certainty "mismatched", such as positive phrases communicating small probabilities (e.g., a slight possibility) or negative phrases communicating high probabilities (e.g., not completely certain). In those cases, the vague probabilistic meaning should not predict directionality (Honda & Yamagishi, 2006) and the greater dispersion may therefore be due to the location on the probability scale instead to the directionality itself.

VERBAL PROBABILITIES: TWO FEATURES TO CONSIDER?

In contrast to the quantitative approach, a more qualitative approach claims that the effect of verbal probabilities on attention is not caused by the vague probabilistic meaning they convey but by a separate linguistic feature (Honda & Yamagishi, 2006; Juanchich et al. 2010; Moxey & Sanford, 2000; Teigen & Brun, 1995, 2003a). According to this approach, verbal probabilities can direct the hearer's attention either to the occurrence of the target event, or to its non-occurrence, regardless of whether they communicate a probability above or below 0.50. In support of this hypothesis, some positive verbal probabilities communicate a probability below 0.50 (e.g., there is a small chance) and some negative verbal probabilities communicate a probability higher than 0.50 (e.g., it is not completely certain). According to the qualitative approach, directionality is not determined by a vague probabilistic meaning conveyed but by situational and linguistic cues, such as framing. For example, a probability based on a positively framed frequency (e.g., number of students who passed an exam) was communicated with a positive verbal probability whereas the same quantity described with a negative frame (e.g., the number of students who failed) was described with a negative verbal probability (Teigen & Brun, 2003b). More recently the studies of Juanchich et al., (2010) supported the claim that directionality was chosen to mark a contrast with a verbal probability that was previously uttered. Participants chose a positive expression to give a probability resulting from an upward revision ($0.10 \rightarrow 0.40$), whereas they preferred a negative expression to give the same probability but resulting from a downward revision ($0.70 \rightarrow 0.40$).

Many findings support that directionality is determined by contextual factors beyond the *mean* vague probabilistic meaning associated with the

expression. Yet these results did not bring definitive evidence in the debate because the *vague* probabilistic meaning conveyed by the expression studied was not controlled for (Budescu et al., 2003). In fact, directionality preferences deemed to be due to context could be accounted for by the vague probabilistic meaning conveyed by the expression studied. For example, in Teigen and Brun (2003b), people might have preferred a negative expression to communicate a negatively framed frequency, not because the expression has a negative directionality but because it is associated with a vague low probability that is positively skewed. This explanation has never been explored and remains a possibility.

The contradictory nature of the findings derived from the two accounts of verbal probabilities could indicate that the truth lies in between. It is possible that directionality is partially dependant on the vague probabilistic meaning but also sensitive to contextual factors.

WHAT IS AT STAKE IN THE CONTROVERSY OVER THE DIRECTIONALITY OF VERBAL PROBABILITIES?

Determining whether directionality is a function of the vague probabilistic meaning conveyed by verbal probabilities or by a separate and context-dependent feature may have consequences on theories, methods, and applications of risk communication research. Evidence supporting the notion that directionality is a function of the vague probabilistic meaning conveyed would legitimate and strengthen an exclusive focus on vague probabilistic meaning when creating samples of expressions (e.g., Budescu et al., 2003), scales (e.g., Windschitl & Weber, 1999) or risk communication guidelines (e.g., Budescu, Broomell, & Por, 2009; IPCC, 2007). Conversely, findings supporting the position that directionality is not a function of the vague probabilistic meaning but is a separate and context-dependent feature would result in the mitigation of previous findings and risk communication recommendations.

For example, to ensure a consistent risk communication strategy, the Intergovernmental Panel on Climate Change (IPCC) recommends the use of seven verbal probabilities to quantify the uncertainty of its forecast (IPCC, 2007). This list includes negative low-probability expressions (e.g., very unlikely) and positive high-probability expressions (e.g., very likely) but does not include positive low-probability expressions (e.g., a small chance) or negative high-probability expressions (e.g., it is not completely certain). Thus the IPCC list entails a complete overlap between attention focus and probabilistic meaning. If attention focus is a function of vague probabilistic meaning, it is legitimate to create a scale where directionality and vague probabilistic meaning are confounded. On the other hand, if directionality is a separate property from vague probabilistic meaning, the IPCC list presents

a methodological limitation: The effect of directionality and vague probabilistic meaning are entangled, which could create biased risk perception and ill-informed decision making. This issue could be avoided by taking both directionality and vague probabilistic meaning into consideration and by creating, for instance, a list of positive expressions to convey low to high degrees of certainty (Sirota & Juanchich, 2012).

GOAL AND HYPOTHESES

To study the factors that affect directionality we investigated individual choice of verbal probabilities as a function of the base rate of an event's occurrence (i.e., frequency of guilt of a suspect) and its representativeness (i.e., propensity of the suspect to be guilty). The quantitative hypothesis implies that the parameters of the membership-functions will mediate the effect of the base rate and representativeness on directionality. On the other hand, the qualitative hypothesis implies a direct effect of the base rate and the representativeness on the membership-function parameters and on directionality. Moreover, we propose to test a third hypothesis, a hybrid of both the quantitative and qualitative account of verbal probabilities. This hybrid hypothesis suggests that directionality might be determined by vague probabilistic meaning but also by base rate and representativeness directly. Thus this hypothesis features a partial mediation. The models tested are depicted in Figure 2.

METHOD

Participants

Participants were 321 members of the National Center for Scientific Research bank of participants[1] (214 women, 103 men, 4 did not specify their gender; 18–66 years, $M = 29.85$, $SD = 9.62$). Participation was voluntary and unpaid. The sample was composed of individuals interested in cognitive sciences with related occupations (i.e., Around 30% students, 30% researchers, 8% teachers, 5% psychologists).

From this initial sample we excluded 72 cases in which participants did not follow the instructions (e.g., did not give a verbal probability but a verbal frequency or a numerical probability in letters). As a result, we conducted the subsequent analysis on a sample of 249 participants (169 women, 76 men, 4 with unspecified gender; age range 18–66 years, $M = 29.10$ years, $SD = 9.20$ years).

[1] CNRS – Reseau interdisciplinaire en sciences cognitive).

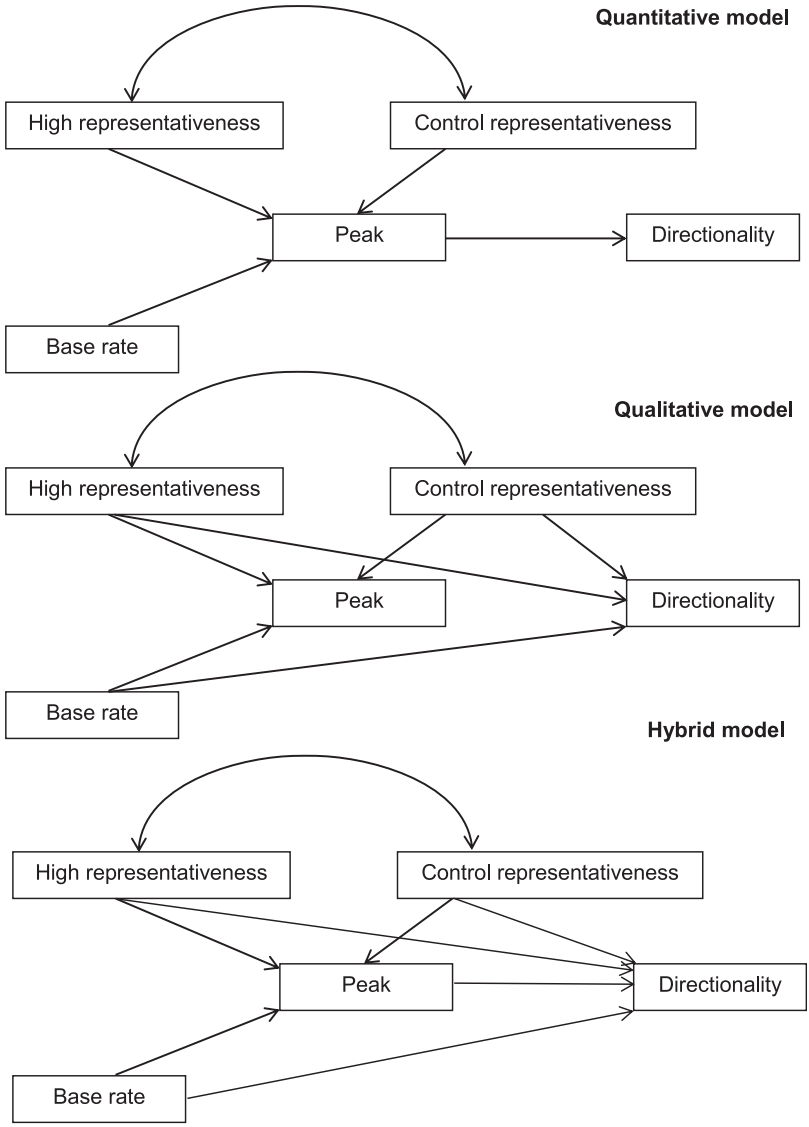

Figure 2. Quantitative, qualitative, and hybrid models tested.

Materials and procedure

The experiment had a 2 × 3 between-participant design, with Base Rate Magnitude (Low vs High base rate) and Representativeness (Low, High, and Control) as independent variables. The base rate of guilt was either low: *2 out of 10 suspects in similar conditions were guilty*, or high: *8 out of 10 suspects in similar conditions were guilty*. In the low representativeness condition the suspect was employed in a small bank and had been suspected in a different type of case (i.e., insurance fraud). In the high representativeness condition the suspect was unemployed and had been previously suspected in a similar case (i.e., a hold-up). Table 1 shows the suspect's description used to manipulate representativeness. In the control representativeness condition participants did not receive information about previous cases involving the suspect or about his job situation. The descriptions of the suspect were pre-tested to determine the perceived propensity of guilt of the suspect. In a between-participants design ($N = 79$) participants judged that the representative suspect had a higher propensity to be guilty than the less representative suspect ($M_{low} = 2.10$, $SD = 1.09$; $M_{high} = 3.45$, $SD = 1.06$); $t(77) = -5.55$, $p < .001$, $d = -1.25$.

All participants read a scenario describing a bank hold-up for which a suspect was interviewed. The suspect was a man described either as moderately or highly representative of a bank robber, according to the experimental condition. Participants also read the base rate of guilt for similar suspects in similar cases, which was either low or high. Based on the representativeness and the base rate, participants gave the probability of the suspect's guilt with a verbal probability by writing an expression of their choice in a blank space. On subsequent pages participants assessed the directionality and the membership-function of the verbal probability they had produced.

Directionality was measured by means of an adaptation of the Causal Completion Task (Honda & Yamagishi, 2006). Participants rated to what

TABLE 1
Description of the suspect as a function of the representativeness condition

Representativeness	*Description*
Low	Mr C is a manager in a small bank. He was recently implicated in a fraud investigation involving two million Euros. Mr C was arrested and charged with insurance fraud and identity theft. The charges were later dropped due to lack of evidence.
High	Mr C is unemployed. He was recently implicated in an armed robbery involving two million Euros. Mr C was arrested and charged with robbery, possession of a weapon, and assaulting a police officer. The charges were later dropped due to lack of evidence.

extent their statements were appropriate when completed with a reason supporting guilt (pro-reason statement) and with a reason supporting innocence (con-reason statement). Judgements were given on two 7-point scales, ranging from 1: *not at all appropriate* to 7: *completely appropriate*.

- Pro-reason. "[Verbal probability produced] that the suspect is guilty because we found his fingerprints at the crime scene".
- Con-reason. "[Verbal probability produced] that the suspect is guilty because someone saw him somewhere else at the time of the offence".

The vague probabilistic meaning conveyed by the expression produced was measured with the Multi-Stimuli-Method (MSM; Budescu et al., 2003). Participants rated to what extent their verbal probability could communicate each of the probabilities of the 0.1–1 axis by increments of 0.10. Ratings were made on a 10-point scale ranging from 1: *absolutely not* to 10: *absolutely*. Specifically, participants first rated to what extent the verbal probability produced could communicate a probability of 10%; then to what extent this same statement could communicate a probability of 20%; and so forth until giving a rating for 100%.

At the end the basic socio-demographic data (i.e., age, gender, education) were collected.

Variables of interest

The directionality score, which reflects the direction of attention generated by the verbal probability on either the occurrence or the non-occurrence of the target outcome, was computed by subtracting the score of appropriateness of the pro-reason from the scores of the con-reason (Honda & Yamagishi, 2006). Directionality score thus ranged from –6 to 6, where negative scores indicated a negative directionality and positive scores a positive directionality.

Peak and skew were derived from the membership-functions using Budescu et al.'s (2003) formula. Peak was the average probability to which the participant assigned the highest membership value. The skew was the difference between the support of the function to the right and left of the peak (|Max – Peak| – |Min – Peak|). Min (Max) was the lowest (highest) probability with a non-zero membership.

RESULTS

Verbal probabilities produced and their characteristics

Overall, participants produced 68 verbal probabilities to describe the likelihood that the suspect was guilty. The four most frequent verbal probabilities

TABLE 2
Directionality, peak, and skew of verbal probabilities

	Low base rate			*High base rate*		
Rep	*Dir.*	*Peak*	*Skew*	*Dir.*	*Peak*	*Skew*
Low	–4.00 (2.64)	14.40 (04.58)	0.82 (0.27)	2.21 (2.52)	75.16 (24.82)	–0.48 (0.64)
High	–3.74 (3.15)	24.66 (21.29)	0.62 (0.57)	3.18 (2.77)	78.63 (25.02)	–0.52 (0.67)
Control	–3.48 (2.91)	16.09 (4.75)	0.83 (0.29)	4.15 (1.62)	81.11 (17.93)	–0.55 (0.60)
Total	–3.79 (2.87)	18.62 (14.24)	0.75 (0.42)	3.46 (2.42)	78.05 (23.13)	–0.51 (0.64)

Means (standard deviations) of the directionality, peak, and skew of verbal probabilities produced as a function of the base rate of guilt and the representativeness of the suspect (Rep). $N = 249$.

were: "it is slightly probable" (11.8%, $n = 29$), "there is a great probability" (10.6%, $n = 26$), "there is a large chance" (7.8%, $n = 19$), and "it is strongly probable" (6.5%, $n = 16$).[2] Most of the less-frequent verbal probabilities produced (41 out of 68) were stated only once (frequency of 0.4%).

The peak, skew, and directionality of the verbal probabilities produced are exhibited in Table 2, as a function of the base rate of guilt and the degree of representativeness of the suspect.

In order to test the three hypotheses we employed a path analysis using AMOS software. The models were estimated using a maximum likelihood method and the fit was assessed by five indices: the chi-squared test (χ^2), the standardised root mean squared residual (SRMSR), the root mean square error of approximation (RMSEA), the goodness-of-fit index (GFI) and the comparative fit index (CFI; Byrne, 2010; Jöreskog & Sörbom, 1986).

Three hypothetical models were tested: quantitative (full mediation, four paths), qualitative (direct effect, six paths), and hybrid (partial mediation, seven paths), and statistically compared. Because representativeness had three categorical conditions, it was dummy coded into two dichotomous variables to be integrated in the path analysis (McArdle, 2009). The two dummy coded variables were: High representativeness, which contrasted the high representativeness condition to the low and control ones, and Control representativeness, which contrasted the control conditions to the low and high experimental manipulations. The membership-function parameter Skew was not included in any tested model as it was highly correlated to the variable peak ($r = –.957$), creating a collinearity problem. The peak of membership-functions was chosen over their skew because it was shown to be a better single predictor of directionality (Budescu et al., 2003). The high correlation

[2] Translated from French : Il est peu probable, Il y a une forte probabilité, Il y a de fortes chances, Il est fort probable.

between peak and skew was previously observed (Budescu et al., 2003) and indicates that terms that best convey a high probability (e.g., a peak at the 80% probability value) also have a greater membership area on the left of this value (below the 80% value) and conversely. The correlation may be especially strong here because, depending on the base rate value, participants chose verbal probabilities whose peaks were either well below or above 50% rather than expressions with a membership function peak around 50%.

Path analysis results

Neither the quantitative model, nor the qualitative model reached an acceptable degree of fit—respectively, $\chi^2(5) = 55.69$, $p < .001$; SRMR = .05; RMSEA = 0.20, 90% CI .16 to .25; CFI = 0.92; GFI = 0.92 and $\chi^2(3) = 31.60$, $p < .001$; SRMR = .04; RMSEA = 0.20, CI 14 to .26; CFI = 0.95; GFI = 0.95. This finding indicates that the attention focus created by verbal probabilities is not caused entirely by their vague probabilistic meaning, nor is it completely independent of it. In line with this inference, the hybrid model (see Figure 3), which featured a partial mediation, had excellent fit indices, $\chi^2(2) = 1.03$, $p = .596$; SRMR = .02; RMSEA = 0.00, CI .00 to .10, CFI = 1.00; GFI = 1.00. The incremental benefit of the hybrid model compared to the quantitative and qualitative models was tested by two chi square

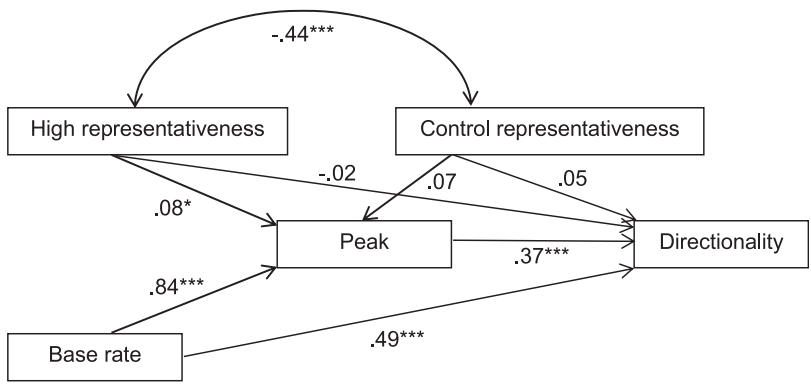

Figure 3. Best-fitting hybrid model accounting for the determinants of the directionality (i.e., attention focus directed either on the occurrence or the non-occurrence of the suspect's guilt) of verbal probabilities. Statistical significance reported here is based on maximum likelihood estimates and is indicated by asterisks (*** $p < .001$, ** $p < .01$, * $p < .05$). Representativeness was dummy coded in two dummy variables: Cont. Rep (control vs experimental conditions) and High rep (high vs low and control conditions).

TABLE 3
Decomposed effects of the best-fitting path model featuring a partial mediation (hybrid model)

	B	*B* 95% CI	β	β 95% CI
Total effects				
Base rate → Directionality	7.20	6.47 to 7.83	$.80^{***}$	.74 to .86
Cont. rep. → Directionality	0.77	0.01 to 1.51	$.08^{*}$	.00 to .15
High rep → Directionality	0.09	–0.80 to 0.84	$.01^{ns}$	–.09 to .09
Direct effects				
Base rate → Peak	0.60	0.55 to 0.65	$.84^{***}$	.77 to .89
Cont. rep → Peak	0.05	0.01 to 0.11	$.07^{*}$	.01 to .14
High rep → Peak	0.06	–0.00 to 0.12	$.08^{ns}$	–.00 to .17
Base rate → Directionality	4.41	2.61 to 6.18	$.49^{***}$	.29 to .69
Cont. rep → Directionality	0.51	–0.28 to 1.26	$.05^{ns}$	–.03 to .12
High rep → Directionality	–0.19	–0.96 to 0.53	$-.02^{ns}$	–.10 to .06
Peak → Directionality	4.65	2.26 to 7.15	$.37^{***}$	.18 to .57
Indirect effects				
Base rate → Directionality	2.79	1.37 to 4.34	$.31^{***}$	.15 to .49
Cont. rep → Directionality	0.25	0.04 to 0.64	$.02^{*}$	.00 to .06
High rep → Directionality	0.28	0.02 to 0.74	$.03^{*}$	.00 to .08

B: Estimated regression coefficients and β: Standardised regression coefficients. Statistical significance and 95% CI based on bootstrapped confidence intervals derived by bias-corrected percentile method; statistical significance is indicated by asterisks ($^{***}p < .001$, $^{**}p < .01$, $^{*}p < .05$, $^{ns}p > .05$). Representativeness was dummy coded into: Cont. Rep (control vs experimental conditions) and High rep (high vs low and control conditions).

differences. Results showed that the hybrid model fitted the data significantly better than the quantitative model, $\chi^2_D(3) = 54.66$, $p < .001$ or the qualitative model, $\chi^2_D(1) = 30.57$, $p < .001$. The direct and indirect effects of the hybrid model are presented in Table 3 and are described below.

The base rate, the representativeness of the suspect, and the peak determined the directionality. The total effect of base rate on directionality was very high ($\beta = .80$). When decomposed, we found an important direct effect of the base rate on directionality ($\beta = .49$) and an indirect effect of the base rate on the directionality mediated by the peak ($\beta = .31$). The indirect effects of the base rate and representativeness on directionality illustrate that the influence of these variables was partially mediated by the peak of the membership function. Furthermore, results indicate that the representativeness of the suspect had a small effect on the vague probabilistic meaning communicated but not on the directionality. This finding further supports that the vague probabilistic meaning and directionality have different determinants.

A bootstrapping method showed the robustness of the hybrid model (see Table 3). The procedure used 2000 re-samples drawn randomly with

replacement from the targeted population and used the maximum-likelihood method of estimation of the confidence intervals (Byrne, 2010).

To summarise, the results of the path analysis support neither the qualitative nor the quantitative hypothesis, but an integrative model based on the two approaches. Results showed that attention focus on the occurrence or the non-occurrence of the target outcome was determined both directly by contextual factors but also by the vague probabilistic meaning of the expression.

DISCUSSION

The goal of this study was to investigate whether the attention focus generated by verbal probabilities on either the occurrence or the non-occurrence of the target outcome was determined by (a) the vague probabilistic meaning conveyed by verbal probabilities, or by (b) contextual factors (i.e., base rate and representativeness), or by (c) a combination of both. The hypotheses were tested based on a set of freely produced expressions in a legal context. The results gave credence to both the quantitative and the qualitative hypothesis by supporting a hybrid model.

In accordance with the assumption that the direction of attention on the occurrence or the non-occurrence of the target outcome was a function of the vague probabilistic meaning (Budescu & Wallsten, 1995), the effect of the base rate of guilt on directionality was partially mediated by the best numerical representation of the verbal probability communicated (i.e., peak). This result replicated the finding of Budescu et al. (2003) on the effect of membership-function parameters on directionality. The analysis also showed that the base rate of the suspect's guilt directly determined directionality and independently so of the membership-function's peak. This result gave credence to the view that attention focus is not fully determined by the vague probabilistic meaning conveyed by an expression (e.g., Teigen & Brun, 1995, 2003a). Overall, the vague probabilistic meaning of verbal probabilities was an important predictor of directionality but failed to fully capture this feature of verbal probabilities.

When communicating the guilt of the suspect, participants did not use the whole spectrum of verbal probabilities. They preferred to communicate low base rates with negative verbal probabilities (e.g., "it is improbable that the suspect is guilty") rather than with positive verbal probabilities (e.g., "there is a small chance that the suspect is guilty"). Along the same lines, they preferred to communicate high base rates with positive verbal probabilities (e.g., "it is probable") rather than with negative verbal probabilities (e.g., "it is not certain that the suspect is guilty"). This pattern of preference weakens the criticism of Honda and Yamagishi (2006) concerning the sampling method of verbal probabilities used by Budescu et al. (2003). Indeed, in light of this result, it seems legitimate to compose a sample of expressions with

negative expressions communicating low probabilities and positive expression for high probabilities.

Yet the spectrum of verbal probabilities produced here might have been influenced by the conversational context in which participants were placed. It is possible that by manipulating the motivation of the participants to stress the innocence or the guilt of the suspect they would have chosen directionality completely independently of the vague probabilistic meaning (e.g., suppose you are defence attorney . . .). Further, the situation in which participants were placed is not very common (assessing the probability of guilt of a suspect), except when on jury duty. It is possible that their lack of familiarity with this type of task led participants to cautiously choose a verbal probability where directionality matched the vague probabilistic meaning. Further efforts to disentangle directionality and vague probabilistic meaning, conducted in more realistic settings, may highlight the conditions in which the vague probabilistic meaning does or does not predict directionality.

Verbal probability choice might also have been limited by the method used; participants chose freely a verbal probability and immediately thereafter provided its vague probabilistic meaning. A drawback of this design is that the numerical probability judgements in the membership-function task could have been anchored by the scenario's base rate or representativeness. Alternatively, the membership-functions for the 68 probability phrases could have been produced in a context-free setting by a separate group of participants.

The present research shows that the vague probabilistic meaning of a verbal probability and the directionality it elicits on the occurrence or the non-occurrence of the described outcome are separate features of verbal probabilities, although vague probabilistic meaning did explain part of the variance in directionality. Consequently, future research focusing on the meaning of verbal probabilities, or on their effect on decision-making, should not only consider vague probabilistic meaning, but should also account for the directionality of verbal probabilities.

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