Implicit Information in Directionality of Verbal Probability Expressions

Hidehito Honda (hito@ky.hum.titech.ac.jp)
Kimihiko Yamagishi (kimihiko@ky.hum.titech.ac.jp)
Graduate School of Decision Science & Technology, Tokyo Institute of Technology
2-12-1, Ohkayama, Meguro-Ku, Tokyo, 152-8552, Japan

Abstract

Many verbal probability expressions (verbal probability) can be categorized into either positive terms (e.g., likely, small chance) or negative terms (e.g., uncertain, poor chance). This distinction reflects the semantic function of communicative focus called "*directionality.*" Previous studies have shown that positive (or negative) terms refer to potential occurrence (or non-occurrence). We conducted two experiments investigating what implicit information was conveyed by directionality. The results show that the verbal probability expressions not only convey explicit probability information, but also implicit information about the speaker's prior beliefs.

Introduction

We often communicate probability information with verbal probability expressions (hereafter called "verbal probability") such as "likely" or "uncertain". Previous studies have shown that many verbal probabilities can be divided into two categories, positive terms or negative terms (Teigen & Brun, 1995). For example, when we communicate low probability, we can say either "There is small chance that…" (positive term) or "There is a poor chance that …" (negative term). According to Teigen and Brun (2003a), positive terms are "pointing upwards, directing our focus of attention to what might happen" (p130), while negative terms are "pointing in a downward direction, asking us to consider that it might not happen after all" (p130). This semantic function of communicative focus is called "*directionality.*" Directionality affects decisions, predictions, and probabilistic reasoning (Teigen & Brun, 1999; Honda & Yamagishi, in press). Because analogous focus has been observed in quantifiers (see General Discussion), the semantic function of directionality can be regarded as a general property in linguistic expressions conveying quantity.

According to Teigen and Brun's (2003a) definition of directionality, the difference between positive and negative terms is in whether the verbal probability points into occurrence or nonoccurrence of an uncertain event. Therefore, if the positive and negative terms denote comparable magnitudes of probability information, they can be assumed to convey explicitly equivalent information. However, recent studies have argued that explicitly equivalent information does not guarantee equivalence of the information (McKenzie, 2004; Sher & McKenzie, in press). If this is the case, then what does the listener infer about an uncertain event from the difference of directionality? Two areas of research are closely related to this question. One is research about judgments of the speaker's optimism, and the other is the research about the listeners' inferences from the selected frame.

Judgment of Speaker's Optimism Based on Directionality

Teigen and Brun (2003b) explored the effects of directionality on the judgment of the speaker's optimism. In their Experiment 2, the participants were presented with a story about a student who was preparing for an important exam. The student described his/her chance to satisfy the requirements using either positive or negative terms, such as "It's possible that I will succeed," (positive term) or "It is not certain that I will succeed" (negative term). Teigen and Brun found that the participants rated the speaker who used a positive term as more optimistic than the speaker who used a negative term even when the verbal probabilities seem to denote comparable probabilities of success. From a normative viewpoint, if the verbal probabilities denoted analogous probabilities, the participants should have judged the speakers as equally optimistic. However, results in Teigen and Brun (2003b) imply that directionality implicitly conveys the speaker's degree of optimism.

Listeners' Inference from the Selected Frame

McKenzie and Nelson (2003) examined listeners' inferences based on the frame the speaker had selected from two logically equivalent expressions. They showed that the listener's inference about the speaker's reference point was systematically different depending on the selected frame. For instance, a 4-ounce cup containing water up to the 2-ounce line can be described as either "half full" or "half empty." McKenzie and Nelson (2003) found that when the cup was described as "half full," the participants inferred that the cup had been previously empty, while when the cup was described as "half empty," the participants inferred that it had been previously full. Thus, the participants made different inferences about the speaker's reference point based on the selected frame. McKenzie and Nelson also demonstrated that listener's inference about the speaker's reference point was consistent with the actual speaker's reference point. McKenzie and Nelson concluded that frames communicate implicit information about the situation in addition to the explicit content of the situation (McKenzie (2004), and Sher and McKenzie (in press) called this "*information leakage*").

Hypothesis of the Current Study

The previous research by Teigen and Brun, and McKenzie and Nelson suggest that even when the verbal probabilities

have comparable strength of uncertainty, connotations due to differences in directionality might diverge.

When a speaker describes an uncertain event with a verbal probability, the utterance could reflect his/her subjective belief (e.g., optimism, Teigen & Brun, 2003b) or known facts of the event (e.g., reference point about the amount of water, McKenzie & Nelson, 2003). The belief or facts could be represented as the prior expectation for the uncertain event. On the basis of this consideration, we propose that the directionality of verbal probabilities conveys implicit information about the speaker's prior expectation for an uncertain event.

Experiment 1 and 2 investigated whether listeners' inferences about the speaker's prior expectation for an uncertain event are different depending on the directionality of the verbal probability. Recall that Teigen and Brun (2003a) characterized positive terms as "pointing upward," and negative terms as "pointing in a downward direction." We predict that listeners infer the speaker's prior expectation on the basis of this communicative focus of directionality. Specifically, our hypotheses are as follows:

(A) For a given current situation (e.g., there is X% that the uncertain event will happen), when listeners hear a positive term about the situation, they infer that the speaker's prior expectation was less than X%.

(B) When listeners hear a negative term, they infer that the speaker's prior expectation was more than X%.

Experiment 1

Method

Participant Three hundred and thirty native speaking Japanese undergraduate students enrolled in an introductory psychology class participated in Experiment 1. They were randomly allocated into one of 6 conditions.

Tasks and Materials In one of the 6 conditions, the participants were presented with the following the story:

> There is a jar with 100 balls. The balls are either red or white. You will be asked to reach into the jar and draw a red ball. You are not allowed to see the contents of the jar. A friend of yours was allowed to see the contents of the jar. The friend found that there were 20 red balls and 80 white balls. Then he said, "There is a slight hope that you will draw a red ball." From this statement, how many red balls do you think that your friend had expected were in the jar before the friend saw the contents of the jar?

The participants then selected either "The friend expected that there were more than 20 red balls" or "The friend expected that there were fewer than 20 red balls." In short, the task was a binary choice between the "more than" and the "fewer than." In the second condition, the participants read the same story except that the friend said "There is a poor hope that you will draw a red ball. In the third condition, the friend said, "It is 20% that you will draw a red ball." Hence, in each condition, the friend's statement was presented with one of the three expressions, a positive term (a slight hope), a negative term (a poor hope), or a number (20%).

In the other 3 conditions, the participants read the same story, except that the number of red and white balls was 50 and the friend's statement was changed into "It is likely that you will draw a red ball" (positive terms), "It is quite doubtful that you will draw a red ball" (negative terms), or "It is 50% that you will draw a red ball" (number). Hereafter, we call each of the conditions, the positive term condition, the negative term condition, or the number condition.

The verbal probabilities[1] describing each of the situations were selected based on the results of a pilot study. The pilot study showed that each of the words had either positive or negative directionality and was appropriate to describe the uncertain events (i.e., 20% or 50%).

Procedure The experiment was conducted in class. The participants were given a booklet which presented one of the 6 conditions. After being given instructions, they read the story in the booklet and answered the question. This took about 5 minutes.

Results and Discussion 1

Table 1 shows the percentages of inference for "more than 20 (or 50) red balls." The results reveal that the listeners' inference about the speaker's prior expectation dramatically varied depending on the directionality of the verbal probability. For the 20-red-balls story, 90.9% of the participants in the negative term condition inferred that the friend's prior expectation about the number of red balls had been more than 20. However, only 39.8% of the participants in the positive term condition inferred that the friend had expected more than 20 red balls. The inference in the number condition was intermediate (78.2%). These three percentages were found to significantly differ (χ^2 (2)=36.45, p<.001). Multiple comparisons between the conditions, using Ryan's method, found significant differences between the positive and negative term conditions (p<.001), and between the positive term and number condition (p<.001).

Next, we examined the specific hypotheses about the listeners' inferences. The participants in the negative term condition inferred that the friend's prior expectation had been more than 20 red balls (p<.001, binomial test), which supports our hypothesis. Although the participants in the positive term condition significantly inferred the friend's prior expectation in the predicted direction, this tendency was not significant (p=.17, binomial test). The participants in the number condition significantly inferred that the

[1] Japanese verbal probabilities used in the present study were: "Wazukanamikomi"(small hope), "Mikomiwaamarinai"(poor hope), "Kangaerareru"(likely), and "Yayautagawashii" (quite doubtful).

friend's prior expectation had been more than 20 balls (p<.001, binomial test).

For the 50-red-balls story, about 70% of the participants in the negative term condition inferred that the friend's prior expectation about the number of red balls had been more than 50. In contrast, only 20% of the participants in the positive term condition made this inference. The inference in the number condition was intermediate (57.7%). These inferences were significantly different between the conditions (χ^2 (2)=27.01, p<.001). Multiple comparisons, using Ryan's method, showed that there was a significant difference between the positive and negative term conditions (p<.001), and between the positive term and number conditions (p<.001). Regarding the specific hypothesis of the listeners' inference, the participants in the negative term condition inferred that the friend's prior expectation was significantly more than 50 red balls (p<.01, binomial test). In contrast, the participants in the positive term conditions inferred that the speaker's prior expectation was significantly fewer than 50 balls (p<.001, binomial test). Therefore, these results confirmed our hypothesis. The inference tendency in the number condition was not significant (p=.33, binomial test).

Taken together, these results support our hypothesis that the listeners' inference about the speaker's prior expectation varied depending on the directionality of the verbal probabilities.

Table 1:
Percentages of inference for "more than 20 (50) red balls."

Experiment 1

20-red-balls story

positive (n=53)	negative (n=55)	number (n=55)
39.6	90.9	78.2

50-red-balls story

positive (n=53)	negative (n=52)	number (n=52)
20.8	69.2	57.7

Experiment 2

20 red-balls-story

positive (n=48)	negative (n=48)	number (n=38)
54.2	100.0	89.5

50 red-balls-story

positive (n=43)	negative (n=47)	number (n=37)
9.3	97.9	54.1

Experiment 2

The results of Experiment 1 might be an artifact arising from the binary choice task. In order to resolve this question, we examined whether our hypothesis could be confirmed using an open-ended method (numerical estimation). The task in Experiment 2 was the same as Experiment 1 except that participants gave a specific number for their inference.

Method

Participants and Procedure Two hundred and eighty native speaking Japanese undergraduate students in an introductory psychology class participated in Experiment 2. They were randomly allocated into one of 6 experimental conditions. The procedure was the same as Experiment 1.

Tasks and Materials The participants read the same stories in Experiment 1. However, instead of selecting from the two responses, they were asked to fill in the blank in the following sentence with a number from 0 to 100: "Before seeing the contents of the jar, your friend expected that there were ( ) red balls in the jar." Hence, the participants had to estimate a number for the friend's prior expectation in stead of choosing between the "more than" and "fewer than" response options.

Results and Discussion 2

Figure 1 displays the results for the 20-red-balls story. The results showed that even for the numerical estimation, the listeners' inferences about the speaker's prior expectation varied based on the directionality of the verbal probability. We conducted multiple comparisons, using Ryan's method, of the mean numbers of estimated red balls. Every pairwise comparison of the three conditions yielded a significant difference (see Figure 1 for significance levels). These results show that inferences about the speaker's prior expectation significantly varied between the three conditions. Thus, our hypothesis was supported. Next, we analyzed the specific hypotheses about the listeners' inferences. We tested the mean numerical estimation from every condition against the null hypothesis that the mean numerical estimation equals 20. In the positive term condition, we found that the inference about the speaker's prior expectation was significantly more than 20 red balls (M=32.14, t(48)=3.45, p<.01). This result is in the opposite direction from our prediction. In the negative term condition, the participants significantly inferred that the speaker's prior expectation was more than 20 red balls (M=52.60, t(47)=22.12, p<.001). This result supports our prediction for the negative term condition. The participants in the number condition also inferred that the speaker's prior expectation was more than 20 red balls (M=43.41, t(47)=9.78, p<.001).

Figure 2 shows the results for the 50-red-balls story. Observe the resemblance between Figure 1 and 2. We analyzed whether the inferences about the speaker's prior expectation were different between the three conditions using multiple comparisons (Ryan's method). There was a signifi-

cant difference between all of the pairs (p<.001). These findings confirm our hypothesis. Regarding the specific hypothesis about the listeners' inference, we carried out the equivalent analyses as we had used for the 20-red-balls story. In the positive term condition, the participants inferred that the friend's prior expectation was fewer than 50 red balls (M=28.94, t(46)=-7.94, p<.001). The inference in the negative term conditions was significantly more than 50 red balls (M=73.00, t(47)=11.72, p<.001). These results are consistent with our predictions. In the number condition, the inference pattern was not significant (M=48.86, t(48)=-0.34, p=.73).

To compare the responses in Experiment 2 to the responses in Experiment 1, where the participants produced categorical responses, we coded the data in Experiment 2 as whether the participant's numerical estimation was "more than 20 (50) red balls" or "fewer than 20 (50) red balls." For example, in the 20 red balls condition, if a participant made a numerical estimation "40 red balls," we coded this as a "more than 20 red balls" inference. Likewise, if another participant made a numerical estimation "10 red balls," we regarded this estimation as a "less than 20 red balls" inference. For those participants answering "20 (50) red balls," we discarded their data from this dichotomous analysis.

Table 1 shows the percentages of "more than 20(50) red balls," inferences in Experiment 2. As Table 1 shows, the results of Experiment 1 and 2 are analogous. For the 50 red balls story, the percentages in the negative term condition relatively differed between Experiment 1 and 2. However, each of the results supports our hypothesis (as previously mentioned, the inference pattern in Experiment 1 was significant). Therefore, our hypothesis does not detract from the difference.

Taken together, the findings from Experiment 1 were almost replicated using numerical estimation in Experiment 2. Furthermore, Experiment 2 mostly confirmed our specific hypotheses about listeners' inferences (the unexpected results of the positive term condition in the 20-red-balls story is discussed in the General Discussion).

General Discussion

In the two experiments, we investigated listeners' inferences about a speaker's prior expectation for an uncertain event based upon the phrasing of verbal probabilities. The results revealed that the directionality of verbal probabilities influenced how the listener interpreted the speaker's implicit intention. Our specific hypotheses about listeners' inferences were confirmed using two tasks, an inference task with a binary choice (Experiment 1), and numerical estimation (Experiment 2).

For the 20-red-balls story, the inference pattern in the positive term condition was not exactly consistent with the prediction from our hypothesis. In particular, in Experiment 2, the participants in the positive term condition made the opposite numerical estimations from our prediction. We speculate that the inequality in the number of candidates between the two inferences (the "more than" and "less than") caused these unexpected results. In the 20-red-balls story, the "more than" inference has 80 candidates as to the number of red balls (from 21 to 100). The "less than" inference, however, has only 20 candidates for the number of red balls (from 0 to 19). This inequality might have led the participants to prefer the "more than" inference in the 20-red-balls story. Here, we focus on the results in the number condition. Teigen and Brun (1999) claimed that numerical probabilities are equivocal in terms of the directionality. According to this claim, the results in the number condition would reflect general tendency of inference pattern immune from the effect of directionality. In the 20-red-balls story,

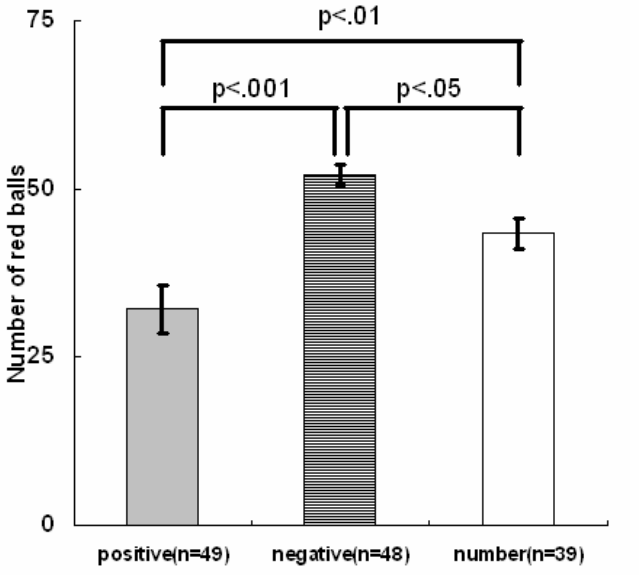

Figure 1: Means of numerical estimation for the friend's prior expectation for red balls in the 20-red-balls story.

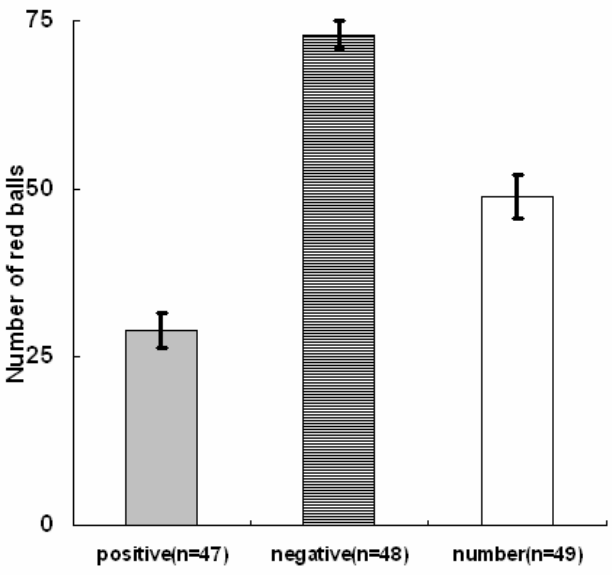

Figure 2: Means of numerical estimation for the friend's prior expectation for red balls in the 50-red-balls story.

the participants in the number condition showed significantly "more than" inference in both Experiment 1 (binomial test, $p<.001$) and Experiment 2 (binomial test, $p<.001$).

On the other hand, in the 50-red-balls story, each of the inferences equally has 50 candidates as to the number of red balls (from 51 to 100 for the "more than" inference, from 0 to 49 for the "less than" inference). Based on the perspective of the number of candidates, we should not find any tendencies for the inference pattern. We also examined this hypothesis in the number condition. In Experiment 1, the participants did not prefer the "more than" inference ($p=.20$, binomial test), and neither did in Experiment 2 ($p=.74$, binomial test).

Taken together, these results indicate that the number of candidates of red balls influenced the inferences about the speaker's prior expectation. However, note that the basic point of our hypotheses (that directionality influences the inference pattern, and people infer a higher probability for the speaker's prior expectation when they hear a negative term than when they hear a positive term) was supported. Furthermore, the inference pattern found in the positive term condition of the 50 red balls story is consistent with the hypothesis. Thus we do not think that the unexpected results in the positive term condition in Experiment 2 pose a large theoretical problem for our hypothesis.

Finally, we discuss two other issues: previous research related to implicit information in directionality, and implications for effects of directionality on decision making.

Previous Research Related to Implicit Information of Directionality

Moxey and Sanford examined focus effects produced by quantifiers such as "a few," "few," "many," and "not many" (Moxey & Sanford, 1993a, 2000; Moxey, Sanford, & Dawydiak, 2001). They found that negative quantifiers such as "few" and "not many" led to different focus patterns than positive quantifiers (e.g., "a few", "many"). For example, when presented with a statement like "Few students attended the cognitive science class. They ( )" and asked to complete the sentence, people tended to describe a set of students who did not attend the class (e.g., "They studied at the library instead"). On the other hand, when the statement includes a positive quantifier such as "A few students attended the cognitive science class. They ( )," people tended to write about a set of students who attended the class (e.g., "They concentrated on the lecture in the class").

In addition to the difference of focus, Moxey and Sanford claimed that negative quantifiers have the property of introducing a presupposition. For instance, the statement "Few students attended the cognitive science class" introduces the possibility that the writer of the statement might have expected that more students did. Moxey and Sanford (1993b) examined this hypothesis and demonstrated that participants rated the writer's prior expectation as higher for the statements with negative quantifiers than those with positive quantifiers. Moxey and Sanford have also explained the processes of focus generation in terms of the processes of negation for the introduced presumption. "Few" and "A few" seem to convey similar information in terms of proportion. However, the findings of Moxey and Sanford suggest that negative quantifiers convey different implicit information about the writer's prior expectation than positive quantifiers. These findings are analogous to the results of our present study.

Moxey and Sanford have argued that the focus produced by quantifiers has an important role in inducing distinct cognitive processes. Our findings are basically consistent with their idea. In considering the information processing of verbal probabilities, clarifying the role of directionality is necessary.

Implications for Effects of Directionality on Decision Making

A fundamental question is why do the listeners make an inference based on the semantic functions of directionality? We speculate that the most important aspect of this issue lies in the speaker's selection of directionality. Probably speakers choose either a positive or a negative term depending on their prior expectation about the situation. Imagine a situation where a speaker's prior expectation for an uncertain event had been a 20% chance of occurrence, and he/she then found a 40%. In this case, we conjecture that the speaker would express the situation using a positive term. In an opposite situation with a 60% prior expectation and a 40% actual occurrence, we conjecture that the speaker would use a negative term. If this is true, it follows that listeners can successfully infer the speaker's actual prior expectation for an uncertain event.

This discussion has very intriguing implications for explaining the effects of directionality on decisions. Previous studies have shown that directionality influences decision making (Teigen & Brun, 1999; Honda & Yamagishi, in press). These studies have shown that, even when positive and negative terms seem to communicate the same probability, decisions changed dramatically depending on the directionality of the verbal probabilities. These findings suggest that when people make decisions based on verbal probabilities, they make different decisions even in the same situation due to the effects of directionality. The classic normative decision theories would regard such decisions as irrational, because they tell decision makers to make the same decisions in the same factual situations regardless of the wording of the situation.

However, this argument might not be valid when considering the effects of directionality of verbal probabilities. Shifts of decisions stemming from the effects of directionality might imply sensitivity to the speaker's prior expectation. As discussed, the speaker's prior expectation would consist of subjective belief and objective facts. This information could convey relative status information about the current situation (e.g., an increase or decrease of probability from a prior situation). The relative status could be important information in making decisions. Thus, it is premature to conclude that decisions influenced by directionality are irrational. Further empirical research is needed to examine speaker's use of directionality in interpersonal communication settings.

Acknowledgments

This work was supported by Grand-in-Aid for Scientific Research (B), No. 14510093, from Japan Society for the Promotion of Science, to KY.

References

Honda, H., & Yamagishi, K. (in press). Directional verbal probabilities: Inconsistencies between preferential judgments and numerical meanings. *Experimental Psychology*.

McKenzie, C. R. M. (2004). Framing effects in inference tasks-and why they are normatively defensible. *Memory and Cognition, 32*, 874-885.

McKenzie, C. R. M., & Nelson, J. D. (2003). What's a speaker's choice of frame reveals: Reference points, frame selection, and framing effects. *Psychonomic Bulletin and Review, 10*, 596-602.

Moxey, L. M., & Sanford, A. J. (1993a). *Communicating quantities: A psychological perspective*. Hove, UK: Lawrence Erlbaum Associate.

Moxey, L. M., & Sanford, A. J. (1993b). Prior expectation and the interpretation of natural language quantifiers. *European Journal of Cognitive Psychology, 5*, 73-91.

Moxey, L. M., & Sanford, A. J. (2000). Communicating quantities: A review of psycholinguistic evidence of how expressions determine perspectives. *Applied Cognitive Psycgology, 14*, 237-255.

Moxey, L. M., Sanford, A. J., & Dawydiak, E. J. (2001). Denials as controllers of negative quantifier focus. *Journal of Memory and Language, 44*, 427-442.

Sher, S., & McKenzie, C. R. M. (in press). Information leakage from logically equivalent frames. *Cognition*.

Teigen, K. H., & Brun, W. (1995). Yes, but it is uncertain: Direction and communicative intention of verbal probabilistic terms. *Acta Psychologica, 88*, 233-258.

Teigen, K. H., & Brun, W. (1999). The directionality of verbal probability expressions: Effects on decisions, predictions, and probabilistic reasoning. *Organizational Behavior and Human Decision Processes, 80*, 155-190.

Teigen, K. H., & Brun, W. (2003a). Verbal expressions of uncertainty and probability. In L. Macci & D. Hardman (Eds.), *Thinking: Psychological perspectives on reasoning and decision making* (pp. 125-145). New York: John Wiley & Sons, Ltd.

Teigen, K. H., & Brun, W. (2003b). Verbal probabilities: A question of frame? *Journal of Behavioral Decision Making, 16*, 53-72.