

Influences of Language Expressions in Group Decision Making: Exploring Verbal Probability Expressions in Group Discussions with Conversational Agents

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Abstract

This study examined how verbal probability expressions (VPEs) used in group decision-making discussions influence individuals' decision-making processes. An online experimental task was developed to investigate how biased decisions emerge depending on the type of expression used during discussions. Scripted conversational agents were employed to experimentally manipulate the VPEs used during group discussions. 440 participants took part in the online experiment, which controlled two factors: (1) the type of VPEs used by group members during discussions and (2) the type of anchoring group decision. The results revealed an interaction between these two factors when participants perceived the agents as human-like. Specifically, confirmation bias occurred more quickly when positive VPEs were used by the agents and the anchoring probability of the group decision was low (20%). These findings provide valuable insights into the influence of VPEs on probability decision-making during group discussions, highlighting the advantages of utilizing multiple conversational agents for investigation.

Keywords: Group decision making; Verbal probability expressions; Conversational agents; Risky shifts

Introduction

The absence of critical thinking and reality testing has been identified as a contributing factor to groupthink (Janis, 1983). When affected by confirmation bias and expectation-driven probability assessment distortions, groups may develop either overly optimistic or pessimistic evaluations of desired outcomes. In these instances, group communication patterns, including linguistic expressions, tend to align with member expectations, potentially reinforcing confirmation bias and distorting probability assessments. To what extent do these contextual dynamics influence individual decision-making processes during probability judgment discussions? This study investigates how linguistic expressions used in group probability judgments affect individual decision-making processes.

Studies on how individuals' group-based decisions can be biased towards a particular opinion have long been conducted in the area of decision-making (Kugler, Kausel, & Kocher, 2012). It has been found that group decisions lead to riskier decisions called risky shifts (Isenberg, 1986; Stoner, 1968). Such shifts are explained by the individuals and dynamics influencing the increase in the diffusion of responsibility, new informative opinions triggering risk-taking behaviors, and the normative influence of social pressures (Deutsch & Gerard, 1955; Jagau & Offerman, 2018). Despite the large scale of studies, there are relatively few studies focusing on the details

of the role of using expressions during interactions inside the group discussions. This is because the methodological difficulty involved in controlling the factors of interactions in group discussions is costly and requires man-power (e.g. using claque). However, studies in cognitive science have used conversational agents as experimental tools to control the type of interaction (Hayashi, 2018, 2023), which may further be used to investigate the influence of group discussions.

A typical discussion held in group decision-making tasks is conducted after an individual makes a decision (pre-opinion), and then group members discuss if their choice is valid based on their initial choice. Following the discussion, group members make group decisions (majority vote, consensus, averaging, ranking, decision by leader, etc.), and then the participant makes a decision based on the individual decision (post-opinion). Risky shifts were analyzed by comparing the differences between post- and pre-decisions. Opinions posed during group discussions may function as referential points for individuals, but it is unclear what kinds of expressions used in such discussions influence decision-making. Previous studies have investigated how the type of expressions called verbal probabilities expressions (VPE) influence individuals' framing (Teigen & Brun, 1999; Honda & Yamagishi, 2017). Considering these points, this study further investigates how VPE used in group discussions influences confirmation behaviors in group decision-making tasks. This study used multiple conversational agents to control participants' opinions and determine the types of interaction factors that influence the group decision-making process.

Opinion changes in group decision making

Previous research has repeatedly shown that group decision making leads to more extreme decisions than individual decision making, a phenomenon known as group polarization (Myers & Lamm, 1976). A previous study showed that group discussions resulted in the selection of riskier options than options considered individually prior to the discussion. This effect is known as the risky shift (Stoner, 1968). The experiment by Stoner (1968) involved a process in which participants first made individual risky decisions and then discussed the same scenario in groups to reach a common decision. The purpose of the experiment was to determine whether group decisions shifted more toward risk-taking than toward individual decisions. Finally, by compar-

ing the individual's initial decision with the group's decision, we analyzed how the in-group discussion altered the individual's risk assessment.

However, some studies show that certain topics cause people to shift toward safer options (Jagau & Offerman, 2018). The opposite effect is known as risky shifts. Risky shifts are observed in decision-making situations such as taking a shot in a game or investing in an emerging country. Conversely, a cautious shift was observed in situations such as choosing a marriage partner. Group polarization can be caused by social comparisons and persuasive arguments, which can be positive/negative (Fredrickson, 2001). This is a combination of the social comparison motive to respond more desirably than others and the emergence of information supporting the extreme direction, which may lead individuals to become more extreme in their opinions.

Studies have also shown how group members' attitudes and the use of expressions influence group decision-making; for example, the emotional states of group member polarization (Clare & Huntsinger, 2009). Studies on group decision-making suggest that not only individuals' emotions but also the perception of group members' emotional states influence the type of decision-making. Moreover, VPE is commonly used in group decision-making, and rational decisions may be impeded by using verbal rather than numerical expressions (Collins & Hahn, 2018), and this is studied widely. In the next section, we discuss the VPE and its role in groups.

Verbal probability expressions (VPE) in group decision making

People often communicate probabilities verbally (e.g., most likely), rather than numerically (e.g., 25% chance). However, probabilistic information is known to impart bias towards decision-making (Kahneman & Tversky, 1979). For example, expressions may change the likelihood of a preference. If two representations have the same expected value in a gambling task, the lower probability tends to be overestimated as follows: Option A: Earning 5,000 dollars by 0.1 %, Option B: Earning 5 dollars by 100%.

Probabilities expressed numerically are called numerical probabilities (Gideon Keren, 2015), and probabilities expressed verbally are called VPE, as mentioned earlier (Beyth-Marom, 1982). For example, in the case of precipitation probability, there are cases where it can be expressed numerically in the form of X%, while there are cases where it can be expressed linguistically, such as "it will probably rain." VPE has two properties: ambiguity (Park & Budescu, 2015) and directionality (Teigen & Brun, 1995). As for ambiguity, it is known that when people are asked to give a numerical answer to a VPE such as, "there is a small chance," people tend to give fluctuating responses, such as "20 percent" or "30 percent." This type of expression can cause misunderstanding, and it is clear that the direction of VPE influences decision-making. The directional nuance differs between the two expressions, "there is a slight chance" and "there is not

much chance." The former expression points upward, directing our focus of attention to what might happen (Teigen & Brun, 2003). This increases our expectation that it is likely to occur, which can be interpreted as an affirmative or positive expression. The latter expression points downward, prompting us to consider that it might not happen (Teigen & Brun, 2003). This decreases our expectation, making it seem unlikely to occur, which can be interpreted as a negative expression.

Studies have shown that the direction of the VPE influences decision-making. Teigen and Brun (1999) has shown that there are three different ways of expressing either positive, negative, or numerical probabilities that can cause a bias in judgment. Each expression can be expressed in the following way: (1) positive expression: "It has some possibility," (2) Negative expression: "It is somewhat uncertain," (3) Numeric probability expression: "The probability is about 30–50%." Based on the three different ways of expression, Teigen and Brun (1999) investigated the use of these expressions and demonstrated that positive expressions tend to be biased toward positive judgments, whereas negative expressions tend to be biased toward negative judgments. Furthermore, (Honda & Yamagishi, 2017) conducted a similar study using Japanese participants and obtained consistent results. Studies suggest that verbal probabilities have (positive or negative) directionality. Positively directional terms (e.g., high probability) bring to mind the occurrence of an outcome, whereas negatively directional terms (e.g., unlikely) suggest non-occurrence (Dhimi & Mandel, 2022).

Studies in social psychology have shown that impressions formed during group activities can influence the interpretation of provided information. For example, in-group bias research indicates that individuals tend to evaluate information as more credible when it comes from members of their own group, to whom they hold more favorable impressions (Tajfel, Billig, Bundy, & Flament, 1971). Additionally, social categorization research reveals that group membership and affiliated identity can significantly impact information interpretation and acceptance (Hogg, 2001). Consequently, the impressions formed of group members, combined with information presentation methods like VPE, may potentially influence decision-making processes.

However, there are many undiscovered issues regarding the use of VPE in group decision-making discussions. Although studies using VPE to pose phrases for decision-making on a single problem have been conducted, few have investigated the influence of the use of VPE during group discussions in the group decision-making process.

Based on the findings of studies on VPE, it is expected that positively expressed opinions of probability by group members during group decision-making discussions may lead to a larger bias. However, as mentioned in the introduction, there is methodological difficulty in controlling the utterances of members during such group activities. To address this issue, this study investigates the use of multiple conversational

agents.

Considering the above points, the challenge of the current study is to further investigate the role of VPE used during discussions in group decision-making, which influences biased decisions. To address this issue, we used conversational agents to investigate whether VPE can influence group-based decision-making processes. How can risk-taking behaviors be biased by group members using VPE during group decision-making discussions?

Goal and Hypothesis

The goal of this study was to (1) develop an agent-based experimental task for group decision-making and (2) use the experimental paradigm to examine whether VPE presented during group discussions affects individual decision-making. Moreover, throughout the study, we examine whether decision-making changes in the same way as humans, even when an agent is the opponent. We examine the following three hypotheses:

- H1** High-/low-risk proposals in the group will facilitate bias in decision making, where higher risk leads to higher decisions and lower risk leads to lower decisions.
- H2** Proposals given by expressions of positive/negative verbal probability will facilitate bias in decision making, where positive expressions lead to stronger persuasive decisions compared to negative decisions.
- H3** Impressions towards their partners may change the way of interpretation of messages and thus influence on the decision making process.

Methods

Participants

A total of 440 participants were included in the experiment. The participants were recruited through Yahoo! Japan crowdsourcing (<https://crowdsourcing.yahoo.co.jp>). The participants were given 52 PayPay points (52 yen, 0.36 dollars). This study was approved by the Ethics Committee of Ritsumeikan University (reference number: Kinugasa-human-2020-53).

Procedure

The experiment was conducted using an online experiment system originally developed by the authors. We developed a decision-making task implemented using a chat system and created a situation in which participants discussed the content of the task with six conversational agents. These conversational agents were scripted agents which were programmed based on predefined rules based on each experimental conditions (See Experiment design section and table Table1 for the scripts.)

The experimental procedure followed (Stoner, 1968); however, the opponents were replaced with conversational agents in this study. The participants were first (1) instructed

to read the scenario of a decision-making situation, (2) make a decision alone, and (3) move to a discussion section to exchange and express their thoughts on the decisions they made. After discussing with the conversational agents for five turn-taking times, (4) the system automatically aggregated the decisions of the members' individual choices and displayed the results on the computer screen as a group decision. This was manipulated for each experimental condition (see below). After reading the group choice, (5) the participant made the decision alone, and (6) moved on to a questionnaire section to answer questions about their partner's expressions. The experiment lasted for approximately 10 minutes.

Experimental system and task procedure The system was built using a web server (Nginx, version 1.18.0), server-side scripts (PHP, version 7.4.10), RDBMS (MariaDB, version 10.5.5), and JavaScript.

A modified Japanese version of the "career change" scenario used in Wallach, Kogan, and Bem (1962) was employed for this task. The task scenarios were as follows: "You are currently an employee of a large company that is unlikely to go bankrupt. If you work for that company until retirement, you can expect to live as well as anyone else. However, your income may not increase rapidly. One day, a headhunter from another venture company, Company A, approaches you. The headhunter said, "If you become an executive of Company A, your salary will be much higher than it is now. If you do well, you could even become the president of the company in the future. However, Company A is more likely to go bankrupt than your current company."

The participants were able to log into the system by accessing to the provided URL. After entering the system, they were able to read the scenario of the task mentioned in the previous section and decide on the probability of changing their jobs by selecting a pull-down menu. The participants were then instructed to imagine that they were the main characters in the story and decide on the probability of taking the new job mentioned in the scenario. The option was to select from a ten-point scale ranging from "1: take the job if the probability of success is 10%" to "10: take the job if the probability of success is 100%."

After answering their individual choices in (2), the participants were instructed to move on to the discussion section (3). At the beginning of the group discussion, the participant entered his/her opinion in the text chat form. After the participants entered their opinions, the opinions of the members (six conversational agents) were presented in random order. This conversation continued until the participants gave their opinions five times. After the discussion in (4), the participants were told that group decisions would be made based on the aggregated opinions posted by the group members. The group decision was presented on the screen and they moved on to step (5) to answer the question posed in step (2). According to (Stoner, 1968), a shift in probability will be an-

chored by group decisions and discussions.

Experimental design

The experiment used a 3 (group decision: 20%, 50%, 80%) × 3 (VPE: positive, negative, number) between-subjects design. For each experimental condition, the content of the agents’ group discussions was manipulated. The following section describes each factor in detail.

Group decision risk (factor 1) For the first factor, the individual opinions of the agents and conversations in the discussion phase were designed such that when the system aggregated the opinions of all conversations, the group choice was adjusted to either 20%, 50%, or 80%, according to each experimental condition. Table1 presents the manipulation of the agents’ individual decisions for each condition. Each agent (agents 1 to 6) will select the possibility of changing jobs on a ten-point scale: “(1): take the job if the probability of success is 10%” to “(10): take the job if the probability of success is 100%.”

Table 1: Manipulation of each agents decision(1) to (9) by each experimental condition(20%, 50%, 80%).

	20% cond	50% cond	80% cond
Agent 1	(1)	(4)	(7)
Agent 2	(1)	(4)	(7)
Agent 3	(2)	(5)	(8)
Agent 4	(2)	(5)	(8)
Agent 5	(3)	(6)	(9)
Agent 6	(3)	(6)	(9)
Group Decision	20%	50%	80%

Verbal probability expressions (factor 2) Verbal expressions were manipulated based on the agents’ opinions during the discussion phase. Three types of verbal probability expressions were set based on previous studies by Honda, Matsuka, and Ueda (2017). In the positive condition, the possibility expressions were fixed based on possibility, whereas in the negative condition, the possibility expressions were fixed based on uncertainty. For the numerical condition, the possibility was expressed using numerical numbers. Each agent generates opinions based on the rule set in Table1; however, the phrases change according to Table2.

Each agent expresses its opinion based on the rule shown in Table 1 using the prototype expression in Table2. To make the conversations look natural, the generated opinions were expressed slightly differently across the five turns and between conversational agents.

Dependant Variables

This study used two dependent variables. The first dependent variable was the participants’ decision about the probability of accepting a job change in the given scenario. As mentioned in the previous section, the decision scale ranged from 0 % to 100 %, and the participants indicated the probability

of success on a 10-point scale. The difference between participants’ scores before and after the discussion was calculated as an index.

The second dependent variable was a questionnaire on the impressions of the agents. Specifically, the Godspeed Questionnaire (GQ)(Bartneck, Kulić, Croft, & Zoghbi, 2009) was used to assess the participants’ attitudes toward conversational agents. The GQ is a 24-item scale consisting of five sub-scales: “Anthropomorphism,” “Animacy,” “Likability,” “Perceived Intelligence,” and “Perceived Safety.” In this study, we only looked at the scale of anthropomorphism to examine how the participants felt that the agents were human-like.” The participants rated their responses on a 5-point Likert scale (1: do not agree - 5: strongly agree). We used the median to split participants into high and low groups to examine the effect of differences in anthropomorphic evaluations of the agent on decision-making.

Results

Shift on the decision of probability

Figure1 shows the shift in the probability of participants’ decisions.

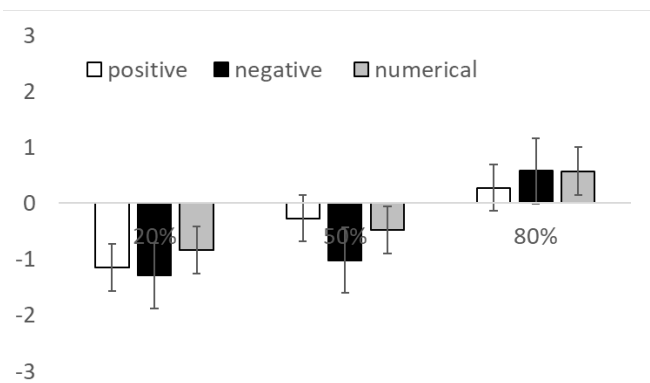


Figure 1: Average score of the shift on the decision of probability. Error bar stands for the standard deviation.

A two-way between-subjects factor ANOVA was conducted to determine the degree of shift. The results show that the interaction was not significant ($F(4, 431) = 1.166, p = .3250, \eta_p^2 = 0.0107$). The main effect of the group decision factor is significant ($F(2, 431) = 29.622, p = .0001, \eta_p^2 = 0.1208$). Multiple comparisons were performed using the Bonferroni method. The 80% group decision condition showed a positive shift compared to the 50% and 20% group decision conditions ($p=.0001; p=.0001$). The 50% group decision condition was also found to have a more positive shift than the 20% group decision condition ($p=.05$). This result supported hypothesis H1. However, hypothesis H2 was not supported. Therefore, We further investigate this point by examining how impressions of their partner’s impression influenced the results.

Table 2: verbal probability expression

	positive	negative	numerical
10	It is certain that changing the job will be a success.	There are no concerns that changing the job will be a success.	It will succeed 100%.
9	It is almost certain that changing the job will be a success.	There are minor concerns that changing the job will be a success.	It will succeed 90%.
8	There is a good chance that changing the job will be a success.	It is quite doubtful that changing the job will be a success.	It will succeed 80%.
7	It is possible that changing the job will be a success.	It is not certain that changing the job will be a success.	It will succeed 70%.
6	It is likely that changing the job will be a success.	It is uncertain whether changing the job will be a success.	It will succeed 60%.
5	There is a small possibility that changing the job will be a success.	It is quite unlikely that changing the job will be a success.	It will succeed 50%.
4	There is some possibility that changing the job will be a success.	There is little hope that changing the job will be a success.	It will succeed 40%.
3	There is a slight hope that changing the job will be a success.	It is unlikely that changing the job will be a success.	It will succeed 30%.
2	There is a tiny hope that changing the job will be a success.	It is almost impossible that changing the job will be a success.	It will succeed 20%.
1	There is a minuscule hope that changing the job will be a success.	It is practically impossible that changing the job will be a success.	It will succeed 10%.

Impact of Partners' Impressions on Shifts in Probability Decisions

Further investigations were conducted based on the assumption that the results shown in the previous section changed because of human-likeness (anthropomorphism). We examined how differences in the degree of anthropomorphic impressions of the agents influenced these two factors. Using the median score from the impressions of anthropomorphism in the god-speed questionnaire, the participants were divided into two groups (high and low anthropomorphism). We subsequently conducted the same ANOVA as in the previous sections for each group and investigated whether the two factors influenced the change in the probability of a decision.

The results of the ANOVA showed a significant interaction between the group decision factor and expression factor ($F(4, 211) = 7.5103, p = .04, \eta_p^2 = 0.0452$). Further analysis of the simple main effect showed that the effect of expression was found under the condition of a group decision rate of 20% ($F(2, 211) = 9.4922, p = .004, \eta_p^2 = 0.029$). Multiple comparisons using the Bonferroni method revealed that the positive condition scored significantly lower than the negative and numerical conditions ($p = .03, p = .01$).

The ANOVA results showed that the interaction between the teaching partner and group solution was not significant ($F(4, 211) = 0.5795, p = .67, \eta_p^2 = 0.0109$). The main effect was significant only for the group solution, which was consistent with the results before grouping ($F(4, 211) = 9.4067, p = .001, \eta_p^2 = 0.0819$).

The results indicate that shifts in probability decisions are influenced by group members' impressions of the agents, particularly their perceived human-likeness. This finding supports hypothesis H3.

Discussion and conclusion

Groupthink can emerge from the absence of critical thinking and reality testing. Under the influence of confirmation bias and expectation-driven distortions, groups tend to make overly optimistic or pessimistic probability assessments of desired outcomes, with their communication patterns aligning to reinforce these biased evaluations. Although decision-making research has been conducted on verbal probability expressions, applied studies on group decision-making have fewer implications, especially regarding how the type of interaction influences conformity. Studies on risky shifts (Isenberg, 1986; Stoner, 1968) in decision-making have

shown that conformity in individuals' choices in probability decisions occurs due to group decisions made by group members. However, it is unknown whether cognitive bias during group interaction has also functioned as a factor for conformity in the decision-making process. Based on the findings of Teigen and Brun (1999) and Honda and Yamagishi (2017) which showed that the probability expressions used in posing the probability of the occurrence of an event influence the shift of opinion, we investigated whether such expressions used by group members during the group discussion (interaction) influence conformity.

To address this issue, this study used a multi-agent experimental paradigm (Hayashi, 2018, 2023) and investigated whether VPEs by group members during group discussions influence the group decision-making process. We developed an experimental system in which group decision-making is conducted online and examined how conformity occurs through discussions with group members in a decision-making task. This study used the task-modified version of the "career change" scenario used in Wallach et al. (1962). Conversational agents were used as group members to experimentally manipulate the expressions of their opinions, and VPE was presented in response to the experimental conditions.

Two factors were manipulated in the experiment: (1) the probability of the group solution calculated when aggregating the decision probabilities presented by the members, and (2) the content of the members' VPE uttered during the group discussion. For (2), we used three types of probability expressions: positive, negative, and numerical. According to Teigen and Brun (1999) and Honda and Yamagishi (2017), positive expressions have stronger persuasive effects on decision-making. In the experiment, we evaluated the impressions of the agents to further investigate whether human-likeness influences persuasion.

The experimental results showed that there was a significant main effect on the conformity shift according to the group decisions (20%, 50%, 80%) generated based on the group discussions. High-risk decisions were made in group decisions under the 80% condition, and low-risk decisions were made in the 20% condition. This is consistent with previous group decision-making studies on risky shift studies (Isenberg, 1986). Our new finding is that these risk-taking behaviors are consistent when conversational agents are used. However, our hypothesis of using VPE to foster persuasion

and boost decision-making was not confirmed in the initial analysis. Therefore, we investigated whether the impression of the agent influenced the decision-making process.

Using the GQ score (Bartneck et al., 2009), we divided the group of participants feeling more human-likeness toward the agents and investigated whether the effects of VPE appeared by dividing them into groups with high human-likeness. The results showed an interaction between the factor group solution and VPE when the participants felt human-likeness toward the group members (Conversational agents). When the probability of a group proposal was low (20%), the use of a positive VPE was associated with the same decision proposed by the group, indicating a conformity effect. This indicates that our hypothesis regarding VPE during conversations in group decision-making discussions is effective in facilitating individuals' decisions. This not only shows new applicable implications in VPE studies but also provides new insight into how Conversational agents' expressions are influential in group decision-making.

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