Title

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Journal

Proceedings of the Annual Meeting of the Cognitive Science Society, 39(0)

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Publication Date

2017

Peer reviewed

On an effective and efficient method for exploiting "wisdom of crowds in one mind"

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Abstract

Previous studies have shown that one can exploit "wisdom of crowds" by oneself. This is achieved by aggregating multiple "quasi-independent" estimates from the same person. However, previous methods were not necessarily easy to utilize. Therefore, we propose an efficient method based on perspective-taking. The procedure is as follows: First, one makes her/his own estimation. Second, one estimates again based on a different perspective ("general public"). Then these two estimations were averaged. Two experiments revealed that our method effectively induced the wisdom of crowds by oneself. More importantly, participants in our method made estimations more quickly than those in a previously proposed method, suggesting that our method required a relatively diminished cognitive load for participants. Further investigation suggested that our method was immune to adverse effects of confidence. Therefore, the present findings show that our method could be effective and efficient method for inducing the wisdom of crowds in one mind.

Keywords: Estimation; Judgments under uncertainty; Perspective taking; Judgment aggregation; Wisdom of crowds; Wisdom of crowds in one mind

Introduction

"Wisdom of crowds" (Surowiecki, 2004) is the well known phenomena, such that the aggregation of multiple estimates made by large number of people is more accurate than the estimate of a single individual. Recently, an intriguing concept, termed "wisdom of crowds in one mind" has been discussed in the research field of judgment and decision making (e.g., Rauhut & Lorenz, 2011). In examining this issue, researchers have discussed how a single person can exploit "wisdom of crowds" in her/his mind. Herzog and Hertwig (2014a) argued that this is achieved by averaging "quasi-independent" multiple estimates from the same person. A person's estimate is not always constant and has some variance, even for the same problem. Using such inconstancy and variance, s/he can exploit the "wisdom of crowds in one mind". For example (see Figure 1), there is a question with correct answer 50%. A person's first estimate was 30%. Imagine that s/he was asked to make the second estimate, then her/his second estimate was 80%. The average of two estimates would be 55%; a result more accurate than the first estimates. Previous studies have proposed some methods about how to exploit the wisdom of crowds in one mind. Vul & Pashler (2008) proposed a method in which individuals make estimations for the same problem twice, with a time lag (2-weeks) between estimations. Herzog & Hertwig (2009) proposed the method called *dialectical bootstrapping*. In this method, people are asked to make an estimation twice. In the second estimation, they are provided an instruction (shown in Table 1, see "dialectical" condition). This instruction asks individuals to provide a different estimation from the first one, by considering new knowledge that was once overlooked, or searching out incorrect assumptions or considerations present in the first estimate. These studies generally showed that the average of the first and second estimates were more accurate than the first estimate, and that the benefit of averaging was larger than in the control condition (i.e., just making estimations twice without any time lag or instructions). Effectiveness of these methods has been confirmed repeatedly in subsequent studies (see Herzog & Hertwig, 2014b for review).

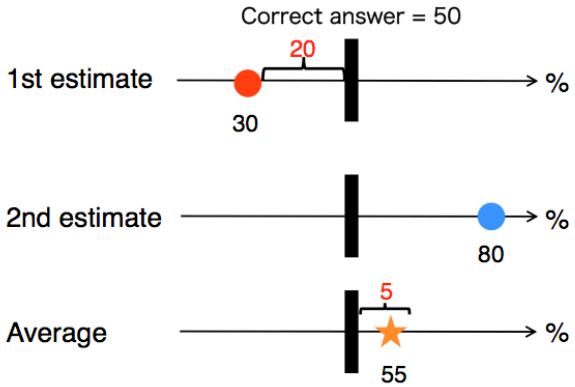

Figure 1. An example of wisdom of crowds in one mind. The red numbers indicate the distance between first or averaged estimate and correct answer.

However, these methods are not necessarily easy to utilize. In the method proposed by Vul and Pashler (2008),

the time lag suggested (i.e., 2 weeks) is necessary to exploit the wisdom of crowds within the mind of a single individual. In the dialectical bootstrapping proposed by Herzog and Hertwig (2009), a rather complicated instruction (Table 1) is necessary. Furthermore, the first estimate has to be presented to the person, which may not be necessarily efficient as a method for inducing the second estimate. In the present study, we propose a new method for exploiting the wisdom of crowds in one mind, based on previous findings on perspective-taking.

Perspective-taking of the "general public" for exploiting the wisdom of crowds in one mind

Perspective-taking

Perspective-taking is the cognitive action to take another point of view. This topic has been examined mainly in the research field of social psychology. Previous studies have revealed that perspective-taking changes peoples' subjective judgment or preference, such as stereotypes about a person (Galinsky & Moskowitz, 2000). Furthermore, recent studies have indicated that perspective-taking prompts people to change estimates about *objectiv*e values (e.g., the population of the city or the date of historical event). Yaniv & Choshen-Hillel (2012) implemented a perspective-taking procedure in the advice-taking paradigm (for more information on the advice-taking paradigm, see Bonaccio & Dalal, 2006 for review). In this experiment, participants were asked to generate an estimate about questions by taking into account estimated values by others (these values were given as *advice*). At this point, participants who were asked to generate estimation at the point of another person's perspective tended to accept advice more than those who were asked to generate their own estimation.

Based on these findings, it is predicted that estimations vary depending on the perspective an individual takes. Accordingly, we propose a method for utilizing wisdom of crowds in one mind by taking others' perspective. In our method, we implemented a perspective-taking procedure in the multiple estimates for the same question, to exploit the wisdom of crowds in one mind. Specifically, we propose the following procedure:

(1): A person makes her/his own estimation.

(2): S/he makes a second estimation based on a different perspective. Specifically, s/he takes perspective of the "general public" (Table 1, see "self-others" condition).

(3): Averaging the first and second estimations.

Merits of perspective-taking of the "general public"

We believe that taking the perspective of the "general public" has some merits. First, different estimation may be easily induced. Although estimations by the same person tend to be analogous (e.g., control condition in Herzog & Hertwig, 2009), people tend to believe that they differ from the general public in some ways. For example, in comparing driving ability, people tend to think that their ability is better than the general public (e.g., Svenson, 1981), suggesting that they believe "I am different from the general public!" Thus, a different estimation may be induced by taking the perspective of "general" individuals. Second, a different estimate may be induced irrespective of confidence about the first estimate. In making estimations, if people are confident about their estimates, they may not change their estimate when they are asked to make the second estimate. Previous studies on overconfidence (e.g., Koriat, Lichtenstein, & Fischoff, 1980) reveal that people tend to be overconfident about the accuracy of their estimation. Thus, in inducing a different estimate from the same person, confidence (especially, as individuals tend to be overconfident) may adversely affect results, as s/he may be reluctant to change her/his first estimate when s/he is confident about the first estimate. For example, in the dialectical bootstrapping method (e.g., Herzog & Hertwig, 2009), people are asked to make the "self" second estimate, even though they are provided an instruction to make a "different" estimate. Therefore, this method may be affected by the confidence in the first estimate, and an appropriately different estimate may not be induced in the second estimate. However, our method may correct for this. The current procedure asks individuals to make the second estimate from "other" people's perspective. Hence, it is expected that our method is relatively immune to the adverse effect of confidence, and the nature of changing the estimate, irrespective of confidence, may result in the effective utilization of the wisdom of crowds in a single mind. Third, anyone can imagine the general public. Leboeuf, Shafir, & Bayuk (2010) showed that when participants were asked to

Table 1. Full text in instruction about three conditions.

Condition	Instruction in the second estimate
Self-others	How do you think people in general estimate about the following question? Make a second estimate after considering fully how people in general estimate about this.
Dialectical	First, assume that your first estimate is off the mark. Second, think about a few reasons why that could be. Which assumptions and considerations could have been wrong? Third, what do these new considerations imply? Was the first estimate rather too high or too low? Fourth, based on this new perspective, make a second, alternative estimate.
Self-twice	No instruction

take the perspective of a particular group ("family" in Study 2), the participants who actually identified with this group ("have a family" in Study 2) preferred the choice corresponding to the perceived group perspective (e.g., a family vacation). However, participants who were not associated with this type of group (e.g., single) were not influenced by this perspective-taking, suggesting that a perspective-taking procedure cannot work effectively for individuals that are not actually associated with the group. Given that people can compare their driving ability with general public (Svenson, 1981), people may be able to imagine the "general" public.

In the following sections, we shall report two behavioral experiments and discuss the effectiveness of our method.

Experiment 1

We conducted a web-based behavioral study in order to examine whether our method effectively induced wisdom of crowds in one mind.

Method

Participants A total of 452 participants were recruited for this experiment through a Japanese internet research company. Participants were randomly assigned into one of three experimental conditions (self-others, n = 150; dialectical, n = 151; self twice, n = 151).

Tasks and materials Participants were asked to answer eight general knowledge questions, such as "What percent of the world's airports are in the United States?" (Vul & Pashler, 2008). Participants answered questions twice following instructions (specific content will be reported the below).

Procedure In all conditions, participants first provided their own estimates about the questions. After answering all the eight questions, participants provided second estimates following the instruction for each condition (see Table 1). In the self-others condition, we instructed participants to take a "general public" perspective. In the dialectical condition, we gave the instruction of the dialectical bootstrapping based on Herzog & Hertwig (2009). In the self-twice condition, no instruction was provided and participants just made second estimate again.

The order of the questions for the first estimate was randomized across participants and that for the second estimate was the same as in the first estimate.

Analysis

In the following analyses, we calculated "% MAD (= mean absolute distance) reduction averaging" (Herzog & Hertwig, 2014a) as an index for the gained accuracy of averaging. First, absolute distance between an estimate and the correct answer was calculated per question for each participant. The mean values of these were computed as MAD. MAD_1 indicated MAD of the first estimates, and MAD_{avg} represents the MAD of the averaged estimates. Then, "% MAD reduction averaging" was calculated for each participant level as follows: $(MAD_1\text{-}MAD_{avg})/MAD_1$.[1] See Figure 2 for examples.

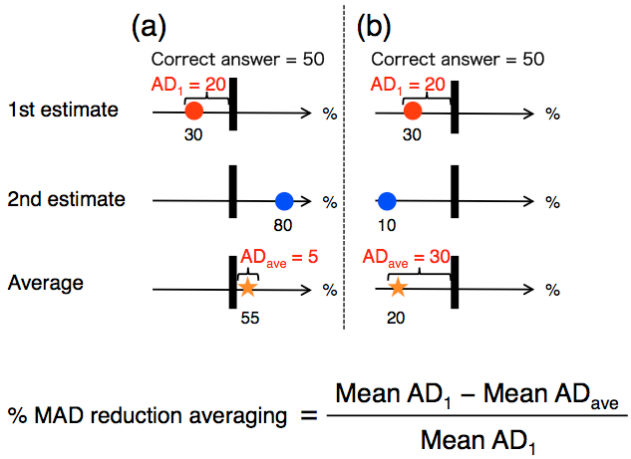

Figure 2. Examples of AD (absolute distance) and formula of % MAD reduction averaging. (a) is an example when averaged estimate is more accurate than first estimate and (b) is an example when averaged estimate is less accurate than first estimate.

Results and discussion

Figure 3 shows % MAD reduction averaging for each condition. In the self-others and dialectical conditions, % MAD reduction averagings were significantly higher than zero (self-others: M = 2.52, CI = [0.08, 4.75]; dialectical: M = 2.20, CI = [0.50, 4.03]). Therefore, averaged estimates reduced error compared to first estimates in these conditions. In contrast, in the self-twice conditions, % MAD reduction averaging was not significantly higher than zero (M = -1.34%, 95% CI = [-3.43, 0.67]). Thus, this method did not

Figure 3. % MAD reduction averaging.

[1] In this paper, a 95% confidence interval was calculated by bootstrapping, based on 1000 sampling, with replacement.

significantly reduce error compared to the first estimates. A pairwise Wilcoxon rank sum test using a Bonferroni correction revealed that in the self-others condition and dialectical condition, % MAD reduction averagings were significantly higher than that in self-twice condition ($p < .01$; $p < .05$, respectively). These results indicate that our method can exploit accuracy of averaging more effectively than the method without any instruction, as with the method proposed in Herzog & Hertwig (2009).

Although no significant differences between self-others and dialectical condition was found ($p > .1$), our method can exploit accuracy of averaging at least as effectively as the method proposed by Herzog & Hertwig (2009) given that the mean value of % MAD reduction averaging in the self-others condition was higher than that in the dialectical condition.

Experiment 2

In Experiment 2, we used the same procedure with the following two exceptions. First, we measured the response time for the second estimate. Second, participants rated confidence about their first estimates, and we analyzed the relationship between the confidence and difference in the two estimates (i.e., first and second estimates).

Method

Participants Japanese graduates and undergraduates from the University of Tokyo (N = 77; 56 men and 21 women; age M = 20.90, sd = 2.52) participated in this experiment. They were randomly assigned into one of three experimental conditions (self-others, n = 25; dialectical, n = 24; self-twice, n = 28).

Tasks and materials Participants were asked to answer twenty questions about general knowledge based on Herzog & Hertwig (2014a). Questions were answered twice, with instructions, as in Experiment 1. In addition, in making first estimations, participants were also asked to rate their confidence for each estimation.

Procedure The experiment was individually conducted using a computer. In all conditions, participants first answered their own estimates about the questions, and rated confidence about their estimates on a 100-point scale. After answering all 20 questions, second estimates were made, following instructions, as in Experiment 1. In the self-others condition, we instructed participants to take the "general public" perspective. In the dialectical condition, we gave the instruction based on Herzog & Hertwig (2009). In the self-twice condition, no instruction was given, and participants simply provided a second estimation.

The order of the questions for the first estimate was randomized across participants and that for the second question was the same as in the first estimate.

Results and discussion

Accuracy of averaging

In the following analysis, as in Experiment 1, we calculated "% MAD reduction averaging" as an index for the gained accuracy of averaging. Figure 4 shows % MAD reduction of the averaging for each condition. In the self-others condition, % MAD reduction averaging was significantly higher than zero (M = 5.51%, 95% CI = [1.26, 9.56]). In contrast, in the dialectical and self-twice conditions, % MAD reduction averagings were not significantly higher than zero (dialectical: M = 2.14, CI = [-1.18, 5.42]; self-twice: M = 1.60, CI = [-0.24, 3.54]). Thus, these methods did not significantly reduce error compared to the first estimates.

Although a pairwise Wilcoxon rank sum test using a Bonferroni correction revealed that in the self-others condition, % MAD reduction averaging was not significantly higher than that in the dialectical and the self-twice conditions ($ps > .1$), the % MAD was higher in the self-others condition compared to the dialectical and the self-twice conditions. Given that the % MAD reduction of

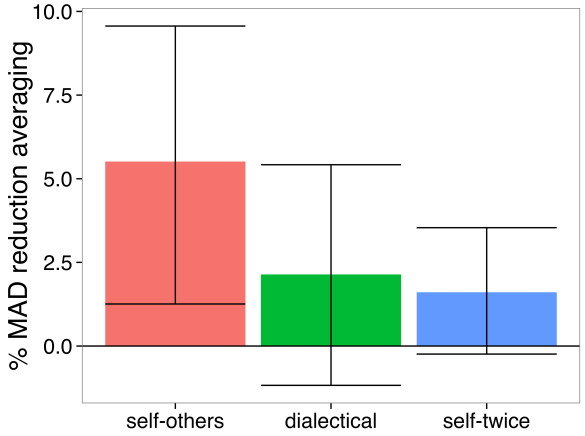

Figure 4. % MAD reduction averaging.

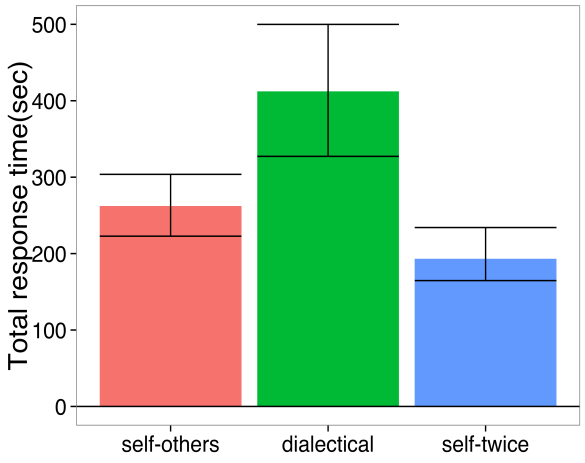

Figure 5. Total response time in the second estimate.

the averaging was significantly higher than zero only in the self-others condition, our method could exploit accuracy of averaging effectively, compared to other methods.

Response time in the second estimates

We analyzed total response time for the second estimate. Figure 5 shows total response time for each condition (self-others: M = 262.27, CI = [222.80, 303.69]; dialectical: M = 412.19, CI = [327.23, 499.90]; self-twice: M = 193.30, CI = [164.67, 234.09].

Total response times were log-transformed and a pairwise t-test using a Bonferroni correction was conducted. It was found that in the self-others condition, participants finished second estimates more quickly than the dialectical condition ($p < .05$). Total response time in self-others condition was longer than that in self-twice condition ($p < .001$). These results suggest that participants in the self-others condition could exploit wisdom of crowds in one mind with diminishing more cognitive load than those in the dialectical condition.

Further examination about the three methods

The difference in first and second estimates To confirm that our method exploited the difference of estimates, in the following analysis, we calculated median absolute distance (AD) to examine the distance between first and second estimates (Herzog & Hertwig, 2014a). Median AD refers to the median absolute distance between the first and second estimates across 20 questions.

Figure 6 shows Median AD for each condition. In the self-others and dialectical conditions, median ADs were both larger than that in the self-twice condition (self-others: M = 8.18, CI = [7.02, 9.28]; dialectical: M = 10.02, CI = [8.48, 11.79], self-twice; M = 2.45, CI = [1.46, 3.46]; pairwise Wilcoxon rank sum test using a Bonferroni correction: *ps* < .001). There was no difference between self-others and dialectical condition ($p > .1$). Therefore, these results showed that our method could induce the difference of estimates as in the dialectical bootstrapping.

Relationship between the difference in first and second estimates and confidence We examined the relationship between differences in the first and second estimates and confidence. Generally, if a person is confident about the first estimate, s/he may not change the second estimate. We predicted that since the participants in the dialectical and self-twice were asked to make "self" estimations, a negative correlation might be observed between the difference in the first and second estimates and confidence (i.e., s/he might not change the second estimate when s/he was confident about the first estimate). However, this might not be true for the self-other condition because a person was asked to make estimate from other people's perspective in her/his second estimate.

We analyzed the relationship between the difference in the first and second estimates and the confidence about first estimate. Absolute distance between the two estimates was calculated for each question within participants, and a correlation coefficient between the absolute difference and confidence in the first estimate was calculated for each participant. [2]

Figure 7 shows distributions of correlation coefficients for each condition. In the dialectical and self-twice conditions, 95% confidence intervals about correlation coefficients were less than zero (dialectical: M = -0.19, CI = [-0.29, -0.086]; self-twice: M = -0.13, CI = [-0.21, -0.060]). In contrast, for the self-others condition, 95% confidence intervals about correlation coefficients included zero (self-other: M = 0.03, CI = [-0.040, 0.10]). These results indicate that participants in the self-other condition tended to make different estimations between the first and second estimations, irrespective of their confidence. However,

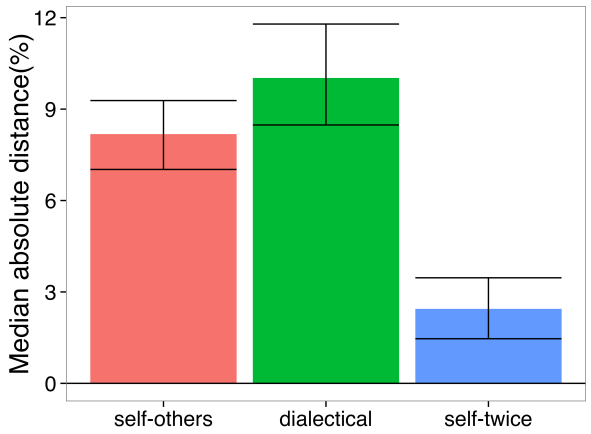

Figure 6. Median absolute distance.

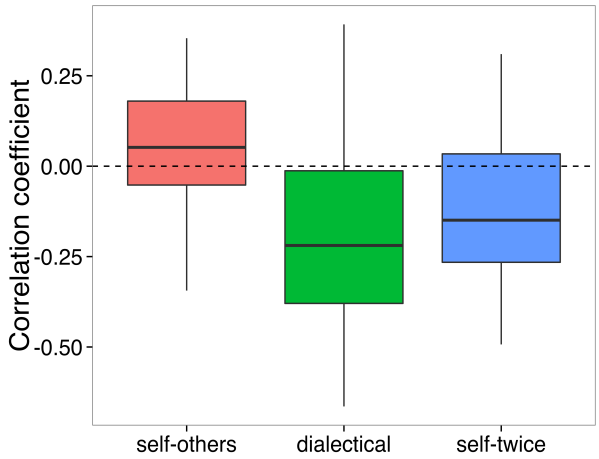

Figure 7. Correlation between confidence and distance.

[2] Two participants in self-others, two in dialectical, and one in self-twice conditions were excluded from analysis, as confidence data was not collected.

participants in the dialectical condition made analogous estimation in the second estimate as in that in the first estimate when they were confident in the first estimate. Given that wisdom of crowds in one mind tends to work when a person makes different estimations in the two estimations (e.g., Herzog & Hertwig, 2009), our method is relatively immune to the adverse effect of confidence compared to the dialectical bootstrapping.

Furthermore, we analyzed the relationship between the accuracy and the confidence in the first estimate. The absolute distance between the correct answer and the first estimate were calculated for each question within participants, as an index for accuracy, and then we calculated a correlation coefficient between these two values for each participant. Figure 8 shows distributions of correlation coefficients. 95% confidence intervals included zero (M = -0.0032, CI= [-0.013, 0.0080]). This result indicates that confidence was not related with the actual accuracy.

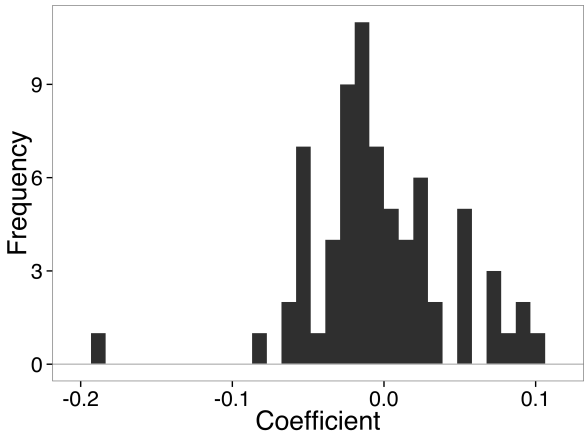

Figure 8. Distributions of correlation coefficient between confidence and distance.

General discussion

In the present study, we proposed a new method for utilizing the wisdom of crowds in one mind, and we examined whether our method was effective when compared to another method proposed in previous studies. Our findings were summarized as follows: First, we found that our method effectively induced the wisdom of crowds in one mind. Second, it was found that participants in our method made estimations more quickly compared to those in the previous method, suggesting that our method diminished cognitive load for participants. Third, we found that our method was relatively immune to adverse effects (e.g., confidence), given that the previous methods require a time lag or presentation of the first estimate (Vul & Pashler, 2008; Herzog & Hertwig, 2009).

Taken together, we believe that our method can be a more effective and efficient method for inducing wisdom of crowds in one mind.

Acknowledgments

This research was supported by Grants-in-Aid for Scientific Research (A, 16H01725) and Young Scientists (B, 16K16070).

References

Bonaccio, S., & Dalal, R. S. (2006). Advice taking and decision-making: An integrative literature review, and implications for the organizational sciences. *Organizational Behavior and Human Decision Processes, 101*, 127–151.

Galinsky, A. D., & Moskowitz, G. B. (2000). Perspective-taking: Decreasing stereotype expression, stereotype accessibility, and in-group favoritism. *Journal of Personality and Social Psychology, 78*, 708–724.

Herzog, S. M., & Hertwig, R. (2009). The wisdom of many in one mind: Improving individual judgments with dialectical bootstrapping. *Psychological Science, 20*, 231–237.

Herzog, S. M., & Hertwig, R. (2014a). Think twice and then: Combining or choosing in dialectical bootstrapping? *Journal of Experimental Psychology Learning Memory and Cognition, 40*, 218–232.

Herzog, S. M., & Hertwig, R. (2014b). Harnessing the wisdom of the inner crowd. *Trends in Cognitive Sciences, 18*, 504–506.

Koriat, A., Lichtenstein, S., & Fischhoff, B. (1980). Reasons for confidence. *Journal of Experimental Psychology: Human Learning and Memory, 6(2)*, 107-118.

LeBoeuf R. A., Shafir E., Bayuk J.B. (2010) The conflicting choices of alternating selves. *Organizational Behavior and Human Decision Processes, 111*, 48–61.

Surowiecki, J. (2004). *The wisdom of crowds.* New York, NY: Doubleday.

Svenson, O. (1981). "Are we all less risky and more skillful than our fellow drivers?". *Acta Psychologica. 47*, 143–148.

Rauhut, H., & Lorenz, J. (2011). The wisdom of crowds in one mind: How individuals can simulate the knowledge of diverse societies to reach better decisions. *Journal of Mathematical Psychology, 55*, 191–197.

Vul, E., & Pashler, H. (2008). Measuring the crowd within: Probabilistic representations within individuals. *Psychological Science, 19*, 645–647.

Yaniv, I., & Choshen-Hillel, S. (2012). When guessing what another person would say is better than giving your own opinion: Using perspective-taking to improve advice-giving. *Journal of Experimental Social Psychology, 48*, 1022-1028.