

AN IMAGE IS WORTH A THOUSAND WORDS, BUT WHAT OF NUMBERS? THE IMPACT OF MULTI-MODAL PROCESSING ON RESPONSE TIMES AND JUDGMENTS OF CONFIDENCE IN BASE-RATE TASKS¹

Marin Dujmović² & Pavle Valerjev
Department of Psychology, University of Zadar

This study introduces images into a well-researched base-rate task. In one set of experimental situations the image represented a base rate consistent or inconsistent with the intuitive answer, and in the second set, a base rate number accompanied the image (multi-modal situation). In the second set of situations the image was equivalent to the numeric ratio, or designed to represent a 60% decrease in the ratio. In both of these situations base rates and images were in conflict with intuitive responses. Consequently, four levels of conflict were induced. After each decision participants made a judgment of confidence. We found a significant effect of conflict level on response times. Higher conflict prolonged response times and lowered rates of intuitive responses. The same effect was not found for confidence, probably due to high judgments overall. We also compared induced levels of conflict by images compared to numeric base rates using data from our previous study. We found a strong overall effect of consistency with slower responses for conflict items. The group by consistency interaction was also significant. Image-based conflict increased response times to a lesser degree than the usual numeric base rates. The same effects were found for confidence ratings. We conclude image-based items induce the same type of effects but to a lesser degree than numeric-based items.

Keywords: base rate task, metacognition, confidence judgment, dual processing, multi-modal processing

Introduction

The psychology of thinking and reasoning has, in large part, been based on the dual-processing approach. A larger number of theories exist, but they are all based on the assumption of two types of processes. Type 1 processes are described as heuristic-based, fast and intuitive. Type 2 processes are described as analytical with higher cognitive load (Evans, 2007).

Pennycook, Fugelsang, and Koehler (2015) suggested conflict monitoring processes are a key mediator between Type 1 and Type 2 processes. They proposed that tasks initiate

¹ This research was supported by Grant 4139 from the Croatian Science Foundation.

² *marin.dujmovic@gmail.com*

intuitive responses, if the responses are inconsistent there is a possibility of conflict detection. Failure to detect conflict results in a dominant Type 1 response while successful detection leads to Type 2 processing which may or may not result in a change of response. All of the mentioned processes are generally done on an unconscious level. This model predicts longer response times when conflict is detected, regardless of the final response.

Work done by Thompson et al. (2013) integrates a metacognitive framework (see Ackerman & Thompson, 2015) into the dual processing approach. Their results show that higher levels of conflict reduce judgments of confidence and that one of the key cues for the formation of these judgments is answer fluency (measured by response times). Research also shows conflict detection can induce an autonomic response (De Neys, Moyens, & Vansteenwegen, 2010) which may contribute to metacognition.

In previous research (Dujmović & Valerjev, 2017) we used a base rate task to investigate the connection between metacognition and conflict. In this task participants were shown a single trait for a random person (e.g. *Person A is organized*) after which they were shown information about the group from which the person was chosen (e.g. *The group consists of 900 artists and 100 lawyers*). The participants had to decide from which subgroup was the person likely chosen. In this example the stereotypical answer is *a lawyer* while the numerically probable answer is *an artist*. For these types of items response times were longer and confidence judgments were lower due to the conflict between responses.

The goal of this study is to determine whether a different modality of the base rate information (images) would produce the same conflict effect on response times and metacognitive judgments. Furthermore, we wanted to investigate if a combination of two types of information (multi-modal base rate) would modulate the effect. Finally, we wanted to compare the pure effect of images and numbers on conflict induction.

Method

Participants and design

Participants ($N = 35$) were undergraduate psychology students. The design was a four level repeated measures experiment. The four situations (Table 1) induced distinct levels of conflict. Two situations presented base rate information through images, and two combined images with numeric information (multi-modal set).

Table 1.
Experimental situations

| Situation | Base rate information and relation to the stereotype | Expected level of conflict |
|-----------|--|----------------------------|
| S1 | Image-consistent | No conflict |
| S2 | Image-inconsistent | Lowest |
| S3 | Image (mitigating) + numeric base rate-inconsistent | Intermediate |
| S4 | Image + numeric base rate-inconsistent | Highest |

Stimuli

Examples of the four situations can be seen in Figure 1.

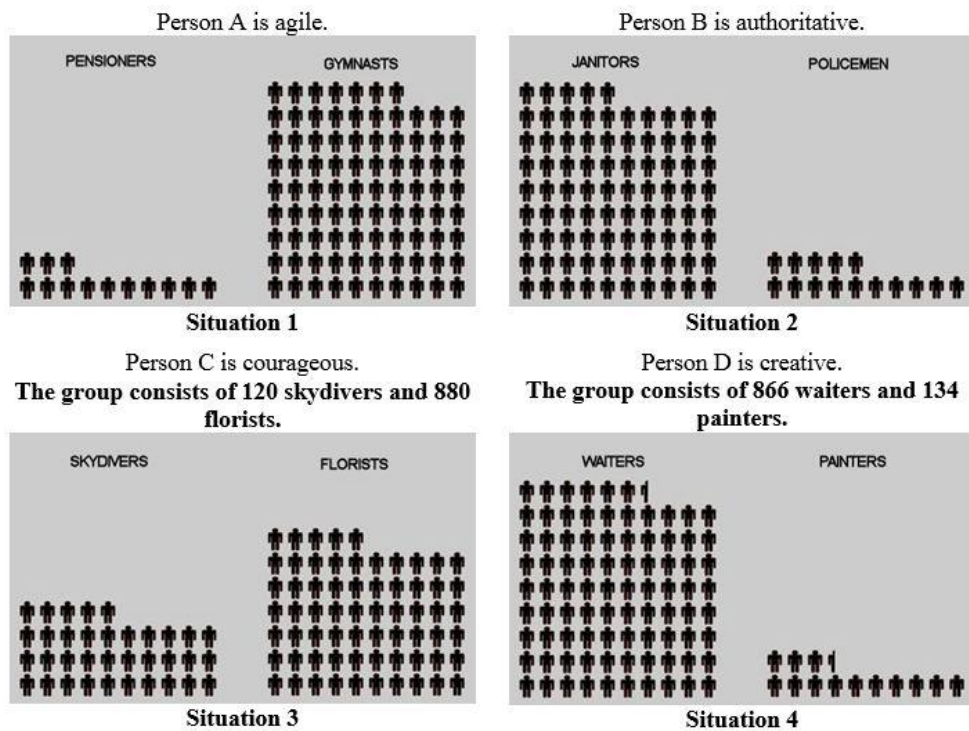


Figure 1. Examples of experimental stimuli

We used items from our previous research (Dujmović & Valerjev, 2017) in order to compare purely image-based items to purely numeric-based items.

Procedure

Each trial followed the basic design from the example in the introduction (Figure 2) Metacognitive judgments were made on a scale from 50% (guessing) to 100% (complete confidence).

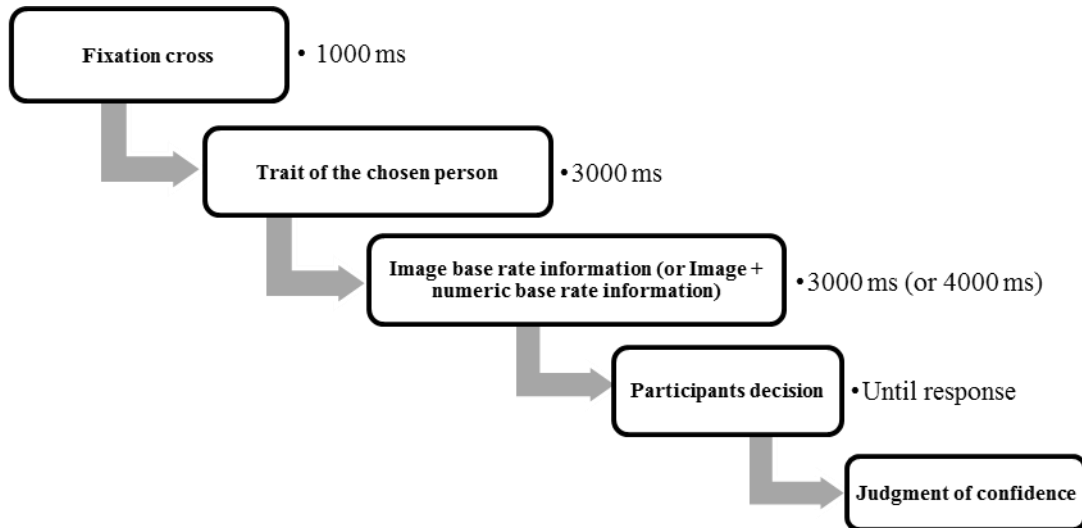


Figure 2. Single trial procedure

Participants completed a total of 20 trials (5 per condition). Trials were presented in two blocks, an image only block, and a multi-modal block. Trials within each block were randomized for each participant. Block order was rotated among participants.

Results

All response time and confidence variables passed normality tests. We verified that block order had no effect on the dependent variables. One way repeated measures ANOVAs were calculated for response times and judgments of confidence. For response times there was a significant effect of conflict level ($F(3,102) = 6.71, p < .01, \eta_p^2 = .16$). Tukey HSD post-hoc comparisons were significant between the non-conflict and the two highest conflict situations. Other comparisons were not significant, but the expected trend was present (see Figure 3).

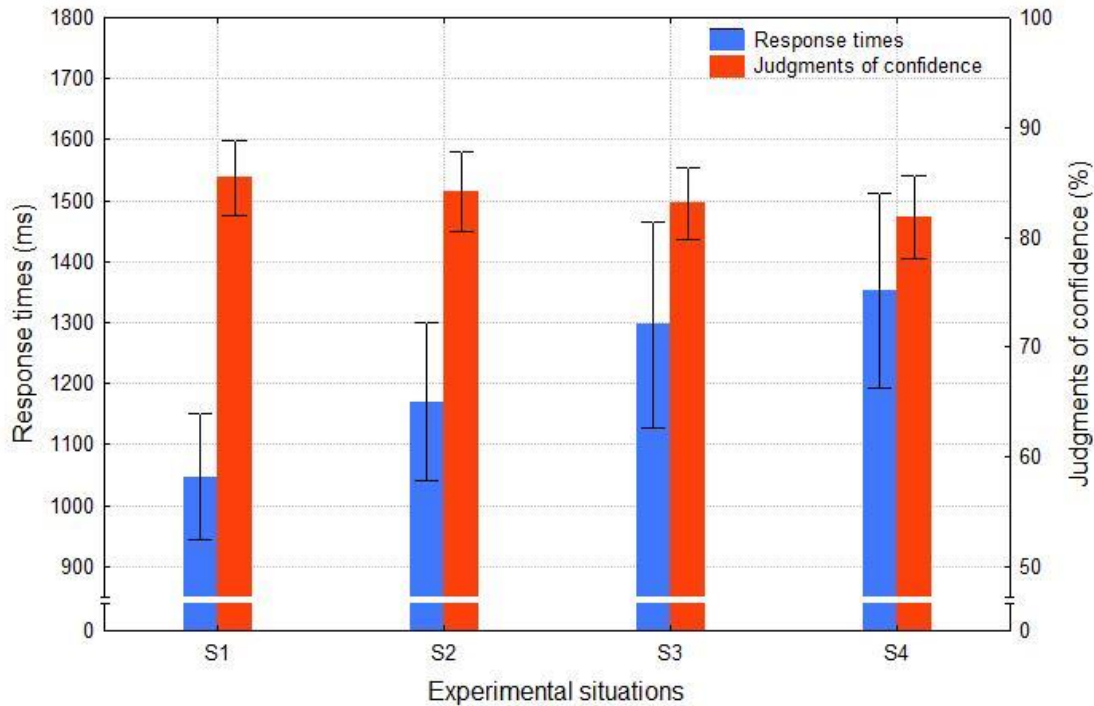


Figure 3. Average response times and judgments of confidence

The same effect was not present for judgments of confidence ($F(3,102) = 1.55, p > .05$). However, the results showed the expected trend. As Figure 3 depicts, conflict slightly reduced confidence judgments.

Stereotype-based response rates were: 94.29%, 81.71%, 76.00%, and 70.29%. As expected, Friedman's ANOVA showed a this decrease was significant ($\chi^2_{(3)} = 19.15, p < .01$).

An item-analysis was conducted to determine whether items with longer response times were accompanied by lower judgments of confidence. Results showed a significant negative correlation ($r_{(18)} = -.59, p < .01$).

Comparison with results from previous experiment

In order to compare the effect of two different modalities of base rate presentation on conflict induction we analyzed data from this and a previous experiment (Dujmović & Valerjev, 2017). Situations 1 and 2 from this experiment were compared to situations in which only numbers provided base rate information. Two 2x2 mixed ANOVAs showed a significant effect of consistency for both response times ($F(1,63) = 30.79, p < .01, \eta_p^2 = .33$) and judgments of confidence ($F(1,63) = 9.67, p < .01, \eta_p^2 = .13$). In general, conflict prolonged response times and lowered confidence ratings. A significant consistency by

modality interaction was found for both response times ($F(1,63) = 7.19, p < .01, \eta_p^2 = .10$) and confidence ($F(1,63) = 4.09, p < .05, \eta_p^2 = .06$). There was a larger effect of conflict when base rate information was presented numerically for both response times and judgments of confidence (see Figures 4 and 5).

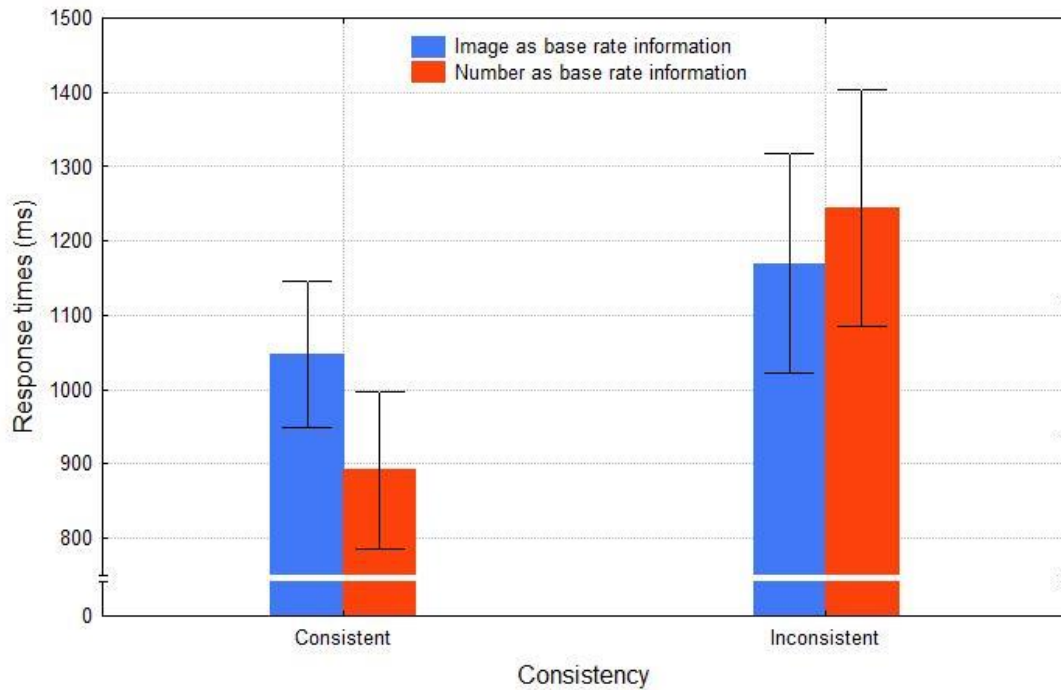


Figure 4. Response times as a function of consistency and modality

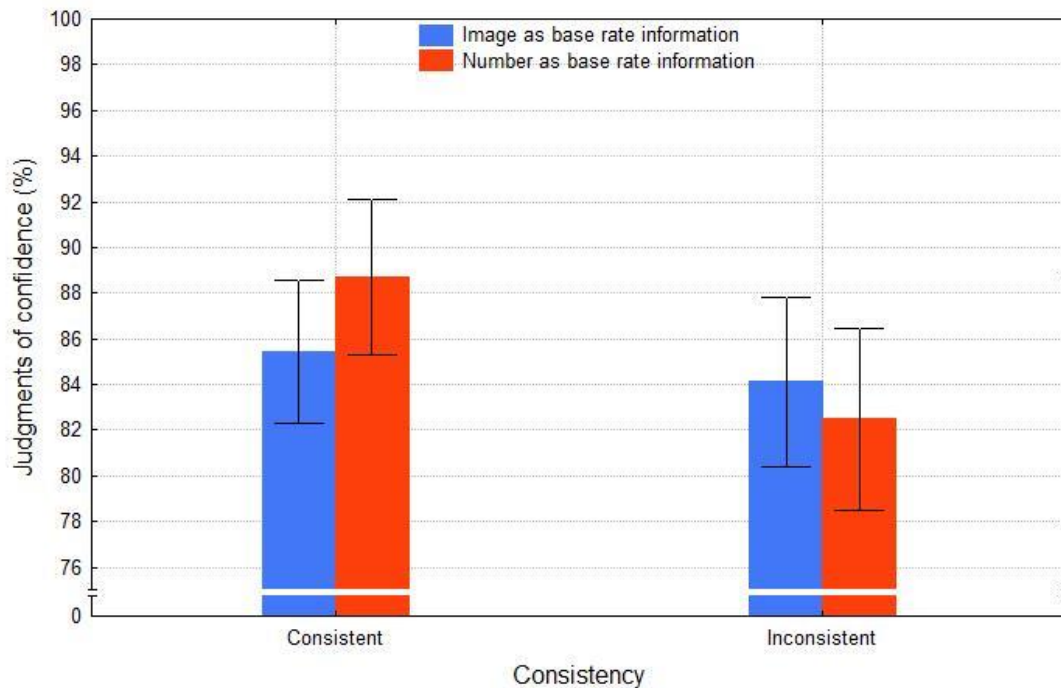


Figure 5. Judgments of confidence as a function of consistency and modality

Discussion and conclusion

As expected, our results showed images can induce conflict in base rate tasks. Furthermore, multi-modal base rate representations enhanced the effect. This multi-modal effect can be fine-tuned by manipulating the level of equivalence of the two information modalities. When image based information represented a 60% decrease of the numerical base rate a lower level of conflict was induced. The effect was strong for response times but not significant for judgments of confidence even though it followed the same trend. This result is likely caused by extremely high levels of confidence in our sample. The impact of conflict on confidence ratings can be observed indirectly from the significant inter-item correlation between response times and confidence. This analysis showed that longer response times (higher conflict level) were accompanied by lower confidence. This correlation has been well documented (e.g. Thompson et al., 2013).

When comparing the pure effect of image-based information with numeric information (Dujmović & Valerjev, 2017) we found that conflict was induced by both modalities, but the effect was stronger when using numeric information. This is probably due to the fact that presentation of numeric information was in the same modality as the rest of the task, particularly the stereotype-inducing trait. Images were probably less salient because of the mismatch in modality with the rest of the task, leading to a smaller effect.

To conclude, the addition of images to the original base rate task increased the conflict effect. Images by themselves induce the effect but to a lesser degree when compared to the numerical version of the task.

References

- Ackerman, R., & Thompson, V.A. (2015). Meta-reasoning: What can we learn from meta-memory? In A. Feeney & V.A. Thompson (Eds.), *Reasoning as Memory* (pp. 164-182), New York: Psychology Press.
- De Neys, W., Moyens, E., & Vansteenwegen, D. (2010). Feeling we're biased: Autonomic arousal and reasoning conflict. *Cognitive, Affective, & Behavioral Neuroscience*, *10*(2), 208-216.
- Dujmović, M., & Valerjev, P. (2017). The influence of conflict monitoring on meta-reasoning and response times in a base rate task. Manuscript submitted for publication.
- Evans, J.St.B.T. (2007). On the resolution of conflict in dual process theories of reasoning. *Thinking & Reasoning*, *13*(4), 321-339.
- Pennycook, G., Fugelsang, J.A. & Koehler, D.J. (2015). What makes us think? A three-stage dual-process model of analytic engagement. *Cognitive Psychology*, *80*, 34-72.
- Thompson, V.A., Turner, J.A.P., Pennycook, G., Ball, L.J., Brack, H., Ophir, Y., & Ackerman, R. (2013). The role of answer fluency and perceptual fluency as metacognitive cues for initiating analytic thinking. *Cognition*, *128*, 237-251.