Valence Matters in Judgments of Stock Accumulation Over Time: An Intervention to Improve Blood Glucose Control and Other Global Problems

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Extended Abstract:

A reasoning error of great societal relevance is the stock-flow failure, in which people often conflate a stock trend with that of its flows. Specifically, people misinterpret the accumulation of a quantity ("stock") and often reason that the accumulation should behave in direct relationship (be positively correlated) with the direction of the rates of change that accumulate ("flows") (Cronin, Gonzalez, & Sterman, 2009). This mistaken reasoning is termed the *correlation heuristic*, and many interventions to mitigate it, including the use of analogies, graphical manipulations, simulations, and learning tools, have been met with little or no success (Dutt & Gonzalez, 2012; Gonzalez & Wong, 2012; Newell et al., 2016).

We suggest that this lack of success stems from a failure to account for the effect of scenario valence (i.e., the "goodness" or "badness" of a situation) on how people associate the direction of an inflow or outflow with the direction of its associated accumulation over time. In accordance with this *valence effect*, Newell and colleagues (2016) found that people performed more accurately on a graphical CO_2 stabilization problem when it was framed as increasing "debt" (and participants regulated spending) than when the problem was framed as increasing "savings" (and participants regulated earnings). Although the two contexts were similarly familiar, the debt frame entailed a solution whose flow direction (decreasing spending) matched the valence of the scenario (debt is "bad," negative valence). The savings frame, however, entailed a solution whose flow direction (decreasing earnings) opposed the valence of the scenario (savings are "good," positive valence).

In the present research, we aimed at furthering our understanding of the valence effect by controlling for (1) the behavior of the stock (increasing or decreasing) and (2) whether the direction of the user-regulated flow coincided with or opposed the direction predicted by the correlation heuristic. We also investigated how the dynamic observation (via video demonstration) of the effects of a particular accumulation trend influenced the accuracy of participants' judgment of a different trend. To these ends, we employed a common health problem: controlling blood glucose through flows of sugar consumption and insulin. We recruited 399 participants through Amazon MTurk and randomly assigned them to one of four conditions in a two-phase 2 (stock behavior: increasing, decreasing) × 2 (flow decision: coinciding, opposing) full factorial design. Using a graph completion task similar to that employed by Newell et al. (2016), we presented participants in Phase 1 with a situation in which they had to determine the level of the outflow (insulin) or inflow (sugar) needed to increase/decrease and stabilize blood glucose by the end of a 100-minute time period. Thereafter, they watched a video that illustrated the solution to the question they

were asked to solve in Phase 1. In Phase 2, participants completed another graph task that had the same stock behavior but the opposite flow decision.

We calculated accuracy in the two phases by subtracting the correct response for each scenario in that phase from the participant's response. To determine the effects of stock behavior and flow decision on accuracy, we then performed 2 × 2 ANOVA on these scores. In both phases, we found significant main effects of stock behavior and flow decision on performance such that participants responded more accurately on problems in which (1) the stock increased rather than decreased and (2) the direction of the flow coincided with rather than opposed the direction of the stock behavior. Most interestingly, we observed partial support for the valence effect in both phases. There were significant interactions between stock behavior and flow decision such that participants in scenarios in which the correct flow decision opposed the stock behavior responded far more accurately when the stock *increased* rather than *decreased*; Phase 1: $F(1, 395) = 27.73$, $p < .001$, $\eta_p^2 = .07$; Phase 2: $F(1, 395) = 12.17$, $p = .001$, $\eta_p^2 = .03$. In other words, we observed the valence effect only when the stock increased (and the correct decision was to decrease the flow). However, when the stock decreased (and the correct decision was to increase the flow), we instead observed the correlation heuristic; participants tended to *decrease* the flow. A possible explanation for this partial support of the valence effect is that the scenarios did not sufficiently convey the valence that we intended. A common conception about diabetes is that blood glucose is always "bad" (i.e., diabetic people always have blood glucose that is too high). Therefore, people's domain knowledge may have led them to (mis)interpret blood glucose as "bad" (as something that must be decreased).

We also examined the average differences in accuracy scores between the two phases to assess the efficacy of the training video. Although significant differences in improvement emerged, with greater improvement for participants who viewed videos in which the flow coincided with rather than opposed the stock behavior, this finding is likely explained by the fact that these participants switched from problems whose solutions *opposed* the correlation heuristic in Phase 1 to problems whose solutions *agreed* with the correlation heuristic in Phase 2.

The main implication of our findings is that one needs to carefully select how to frame the context of a stock and flow problem. To encourage correct responses, one needs to: (1) frame a problem so that the correct response coincides with the correlation heuristic; (2) ensure that the valence of the scenario matches the valence of the correct response when the correct response cannot coincide with the correlation heuristic; and (3) avoid situations in which the correct response coincides neither with the correlation heuristic nor the valence of the scenario. In future research, the effects of the agreement or opposition of the valence of the scenario to the direction of the correct response need to be tested in naturalistic cases of blood glucose control and other global problems.

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