

# ICONIC SIGNS AND STOCK FLOW PERFORMANCE

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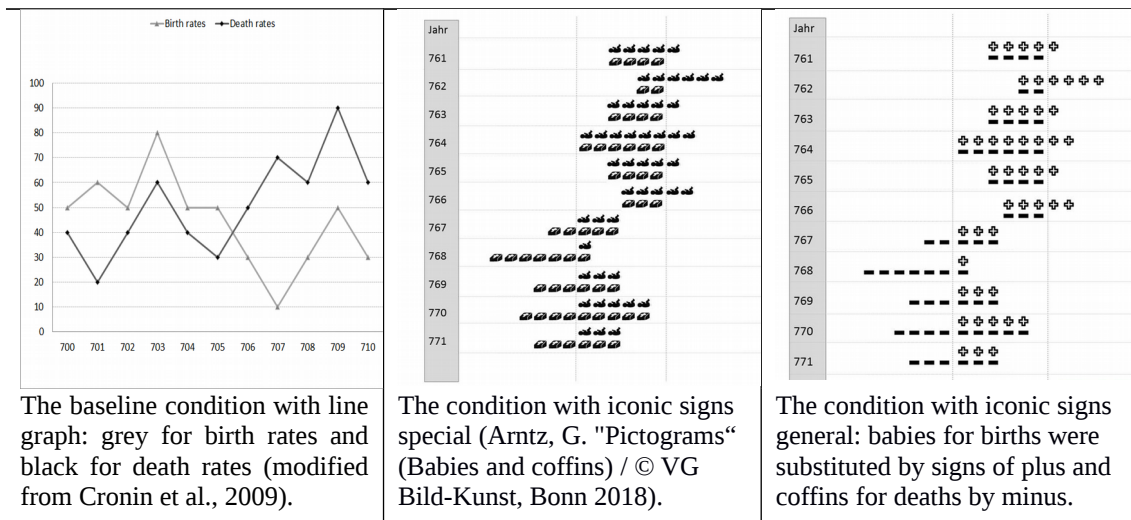
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In our lives, it is very important to understand Stock and Flow (SF) systems. But in many studies, a large number of participants failed finding out the stock's pattern when in- and outflow were given (e.g. Booth Sweeney & Sterman, 2000). Different modifications of the flows' representation were tested to improve SF performance, but they did not help (much) (e.g. Cronin, Gonzalez, & Sterman, 2009). One modification led to strongly improved performance: instead of line graphs, diagrams including pictograms (iconic signs) were shown (Brockhaus, Arnold, Schwarz, & Sedlmeier, 2013). In follow up studies, performance still was better for iconic signs, but the effect decreased (e.g. Brockhaus & Sedlmeier, 2018). In the present study, we tried to overcome some shortcomings of the preceding studies. E.g. in one study each participant had to solve two identical flow patterns as tasks, one shown with pictograms and one with line graphs. The solution rates of the two patterns correlated highly. It was not clear, if participants realized the flow patterns being identical. We wanted to find out if the facilitating effect of using iconic signs could be replicated. We designed the diagrams including iconic signs according to ISOTYPE (Neurath, 1936). Furthermore, we changed the iconic format again to find out, if more abstract signs (plus and minus for inflow and outflow) work as well as the iconic signs with babies representing births and coffins representing deaths as used in preceding studies.

**Methods:** 25 participants solved two tasks with identical flow patterns but different representation format (line graph vs. iconic signs special or general (fig.1)) and a third SF task (with sawtooth pattern as used by Booth Sweeney & Sterman, 2000) between the tasks with identical flow patterns in order to test if participants realized the first and third task being identical by asking them to rate the similarity of the three tasks.



The baseline condition with line graph: grey for birth rates and black for death rates (modified from Cronin et al., 2009).

The condition with iconic signs special (Arntz, G. "Pictograms" (Babies and coffins) / © VG Bild-Kunst, Bonn 2018).

The condition with iconic signs general: babies for births were substituted by signs of plus and coffins for deaths by minus.

Figure 1. Flow graphs of the discontinuous task represented in three different formats

We also controlled the variables gender and mathematical skills since both correlated in the past with SF performance (e.g. Kapmeier, 2004; Lungwitz, Sedlmeier & Schwarz, 2018). The dependent variable was the rate of correct solutions.

**Results:** Taken together, the solution rates did not differ: In the conditions with iconic signs, 36% answered both questions about the stock correctly. In the line graph condition, 32% and 24% respectively answered the questions about the stock correctly. When separated by position, differences depending on the used format can be seen (fig. 2). Participants working on iconic signs first showed better solutions than those starting with line graphs. This still can be seen for the “maximum of stock” when the same task (same pattern but different representation format) was shown again at third position.

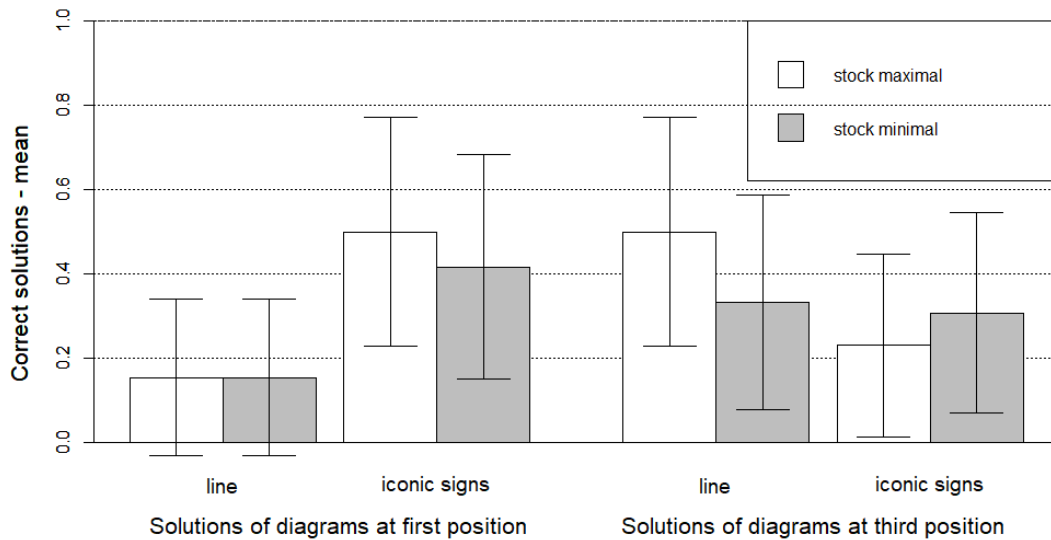


Figure 2. Bar plot showing the mean of the correct solutions for maximal and minimal stock, including 90% confidence intervals; separated by position and format.

Regression analyses were conducted including representation format at first position, gender, and mathematical skills as independent variables. The dependent variable was the rate of correct solutions.  $R^2 = .42$  was significantly different from zero with  $F(3,23) = 4.779, p = .01$ . Gender was the most important predictor (gender:  $\beta = .54, p = .01$  with males performing better). Iconic signs at first position led to better solutions ( $\beta = .45; p = .02$ ); and higher mathematical skills led to better solutions ( $\beta = .31, p = .10$ ). No meaningful differences between the two types of iconic signs could be seen. Moreover, the solutions rates for the discontinuous task in first and third position correlated highly. The participants also had to judge how similar they had perceived the three tasks. Only about one fifth realized the similarity of the first and third task, therefore realizing this seems not to explain the high correlation of solutions completely.

Taken together, it seems that if one wants to achieve higher solution rates in SF related problems, one has to do more than changing the representation format of the flows. But it also seems that one can improve basic SF performance by using iconic signs for the flows.

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