Seeing the forest for the trees predicts accumulation decisions

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Abstract

Stock-flow (SF) systems involving the accumulation of a stock over time are pervasive in many areas of human life. However, people make consistent mistakes when regulating such systems, a phenomenon termed *SF failure*. We introduce holistic (global) versus analytic (local) processing as a cognitive mechanism underlying the hardly understood SF failure. Using a classic SF problem (department store task), we found that (a) solutions to SF problems were up to four times higher when a global task format highlighting global structure compared to a local task format highlighting local elements was used; (b) a more global processing style is connected to higher solution rates to the SF problem; and (c) procedurally priming participants with more global processing results in higher solution rates to the SF problem. In sum, our results point towards global-local processing as a basic explanation for SF failure.

Keywords: Stock-flow failure; global-local processing; dynamic systems.

Many decisions we make in our daily lives are aimed at keeping a system under control, or in equilibrium. For example, we aim at keeping our weight at a healthy stage, don't each too much, don't eat too little; we aim at keeping our bank accounts under control: buy the things that we need but don't spend too much. These types of systems are called *dynamic stock management* problems, where a stock (i.e., accumulation) is influenced by decisions to increase the stock (i.e., inflow) or to decrease the stock (i.e., outflow) (Sterman, 2000). Keeping a stock in balance implies that the outflow equals the inflow, that is, the stock does not change when the rate of increase equals the rate of decrease in the stock.

Dynamic stock management is extremely difficult to master even after extended amounts of practice (Diehl & Sterman, 1995; Paich & Sterman, 1993). The dominant explanation of these difficulties has been *dynamic complexity* (Sterman, 2000): the idea that systems that involve multiple decisions and delays between actions and observable outcomes create complex interdependencies that go beyond our cognitive capacity.

In light of these difficulties, more recent studies have pared back dynamic stock management tasks to their fundamental elements – one stock, one inflow and one outflow – and asked for simple 'one-shot' decisions about the system (Booth Sweeney & Sterman, 2000; Cronin & Gonzalez, 2007; Gonzalez & Wong, 2012; Sterman, 2002). Interestingly, even in these extremely simplified problems, a majority of people performs poorly (Cronin et al., 2009).

This general difficulty in understanding the dynamics of accumulation was termed "Stock-Flow Failure" (*SF failure*). There is very little research, however, aimed at understanding how people make decisions in these types of systems (Cronin, Gonzalez, & Sterman, 2009). For example, it was repeatedly found that people have the erroneous tendency to perceive a stock's behavior as directly related to that of its flows (Booth Sweeney & Sterman, 2000; Cronin et al., 2009; Cronin & Gonzalez, 2007), a tendency termed *correlation heuristic* (Cronin et al., 2009). Although the correlation heuristic seems to be robust in SF failures, it remains a re-description of the typically observed behavior rather than an explanation of *why* the behavior occurs. A goal of the current research is to elucidate some cognitive mechanisms underlying SF failure. Specifically, we introduce Global-Local processing[1] as a fundamental explanation.

We propose that, to make accurate accumulation decisions, one needs to process information globally and not locally. That is, one needs to see the forest and not the trees. For example, to make a prediction about the amount of money in our bank account at a point of time, we need to see broadly the predicted deposits and withdrawals over the preceding time periods.

Processing styles are content-free ways of perceiving the environment (Tulving & Schacter, 1990). In global processing, one attends to objects holistically and focuses on the entire Gestalt by "zooming out"; in local processing, one attends to objects elementally and focuses on its details by "zooming in" (Navon, 1977; Schooler, 2002). Just as a global view on a Navon letter (global letter made up of smaller letters, Navon, 1977) means perceiving the whole form and not its component parts, a global view on dynamic systems should mean perceiving the systems' behavioral patterns and not its constituent parts. This should hold not only for complex systems containing a range of interacting variables, but even for "simple" SF systems, because in either case the behavior of the stock depends on the *relation* between in- and outflow, *aggregated* over time periods. That is, to regulate dynamic complexity in general, an abstraction process is needed from lower-level

[1] We use the term processing in a generic sense to include both perception and cognition. To distinguish both, we use the terms perceptual and conceptual processing, respectively.

representations (e.g. about a specific inflow at a specific point in time) to higher-order representations (e.g., about the overall relation between in-and outflow). We expect such a super-ordinate framework to enable the problem-solver not to view each component in isolation, but to view all components as *structurally related parts of the system*, thus allowing for inferences on the behavior of system as a whole.

To see how a human's tendency to process information globally or locally influences SF-reasoning, we measure individual differences in global-local processing and test participants with two task formats of a commonly used SF problem, the "Department Store" (DS) task (Sterman, 2000; Cronin et al., 2009). We argue that the SF task format that was used previously induced local instead of global processing of the problem and that a representation that induces global processing would lead participants to higher accuracy in their judgments of a stock.

In summary, we investigate the effects of three different aspects of global-local processing on SF reasoning: (a) global vs. local task format of SF problems, (b) individual differences in global vs. local processing and (c) global vs. local perceptual priming.

Procedural Priming of global-local processing

The tendency to perceive the environment locally versus globally does not only exists as a prior bias in participants, but it can also be triggered, e.g. by instructing participants to focus on the global versus the local letters in the classic Navon-letter task (Navon, 1977; Macrae & Lewis, 2002). Moreover, global-local processing styles can carry over to subsequent tasks (*procedural priming*). Such procedural priming must be distinguished from semantic priming in that "the how rather than the what is primed" (Förster & Dannenberg, 2010, p. 176). As predicted by Schooler's theory of processing shifts (Schooler, Fiore & Brandimonte, 1997), procedural priming effects can be *transfer-appropriate* or *transfer-inappropriate*. For example, after global procedural priming, participants generated more creative answers such as original uses for a brick than after local procedural priming (Friedman, Fishbach, Förster & Werth, 2003), thus showing a transfer-appropriate shift.

Procedural priming affects both perceptual and conceptual processing by means of a common attentional mechanism that is used both on the perceptual (e.g. to perceive the global and not the local figure) and the conceptual level (e.g., to select the distant and not the proximal node within the semantic network; Friedman, Fishbach, Förster, Werth, 2003; Förster, 2009). A, say, broadened perceptual scope thus carries over to a broadened conceptual scope, resulting, for example, in more remote associates and higher creativity or the use of broader mental categories (Förster, 2012).

The department store task

In the DS task, participant are presented with a graph showing the rate of people entering and leaving a department store each minute and over a 30-min. interval (Fig.1). The stock is the accumulation of people in the store over the 30-min interval, the inflow is people entering and outflow people leaving the store. Participants are then asked four questions as shown in the figure. The first two questions test whether participants can read the graph correctly, essentially measuring if they are able to identify the inflow and the outflow. The last two questions test whether participants can infer the stock's behavior based on the behavior of the flows over time.

The main measure of SF failure is the typically low solution rates to questions 3 and 4 (see detailed analyses of different kinds of errors in several publications such as Cronin et al., 2009 and Gonzalez & Wong, 2012).

The SF failure was also demonstrated using bar charts, tables or texts listing the specific in- and outflows per minute (Cronin & Gonzalez, 2007; Cronin et al., 2009), for different contents (Brunstein, Gonzalez, & Kanter, 2010), and also when motivation and learning were induced (Cronin et al., 2009). Thus, so far, SF failure has not only proven to be a highly stable construct, but also the involved cognitive mechanisms remain unclear.

We expect global, as opposed to local, processing to be a beneficial cognitive strategy, however, for two reasons.

First, SF problems (or any problem, for that matter) consist of a set of surface details and an underlying relational structure. SF systems all adhere to the same structure: If the inflow exceeds the outflow, the stock increases and vice versa. Even though the SF structure is simple, "seeing" it is not, but is nevertheless crucial for problem-solving. Because local processing means searching for details, whereas global processing means searching for structural relations (Förster, 2009; Love et al., 1999), we expect global processing to be beneficial for detecting the SF structure and thus for problem solving.

Second, global processing was found to be connected to more superordinate category-use (Förster & Dannenberg, 2010). Because processing in concrete and narrow categories (e.g., "In minute five, eight people enter, and in minute six, two people enter") represents an erroneous strategy, whereas processing in abstract and broad categories (e.g., "Overall, more people enter than leave") represents a helpful strategy for making inferences about the overall system behavior such as the stock, we expect global processing to be beneficial for problem solving.

The typical SF paradigm may arguably have primed local perceptual processing, however, because local features such as specific numbers of people were highly salient (Fig. 1). Participants might therefore get the impression that exact numbers need to be retrieved and worked with, thus using local processing. In our reasoning, however, it should be beneficial to induce the impression that specific numbers are merely constituent elements, and that the overall figure, the gist of the display needs to be perceived. Since in the Navon-letter-task, it was found that manipulating the relative salience of the local versus the global form triggered local versus global perceptual processing (see Kimchi, 1992, for a review), we expect a task format highlighting surface elements (local format) to induce local processing and therefore to be detrimental, and a task format highlighting structure (global format) to induce global processing and therefore to be beneficial for SF performance.

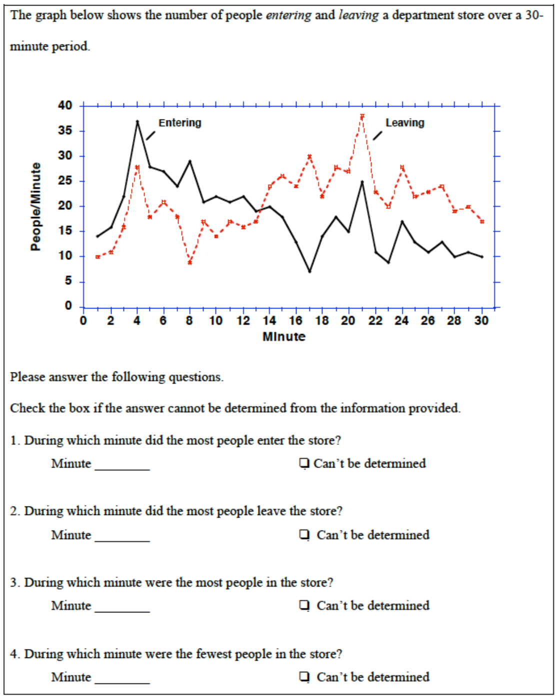

Figure 1. Original department store task format as used in Cronin, Gonzalez and Sterman (2009).

In sum, we expect a connection between global-local processing and stock-flow reasoning. Our test of this assumption is threefold:

1. *Task format hypothesis*: A global task format should enhance solution rates compared to a local task format. We use the same SF problem (department store task) and vary the relative salience of local versus global features.
2. *Individual differences hypothesis*: Individual more global perceptual processing should be connected to higher solution rates to SF problems. We measure global-local perceptual processing style using a variant of the Navon-letter task, the Kimchi-Palmer figures task (Förster & Dannenberg, 2010) and correlate participants' mean score with SF problem-solving performance.
3. *Priming hypothesis*: Priming global perceptual processing should induce a transfer-appropriate, whereas local perceptual processing should induce a transfer-inappropriate shift on subsequent problem-solving. That is, we except induced global perceptual processing to shift to global conceptual processing, resulting in high solution rates in SF problems, and vice versa. We will experimentally induce different perceptual processing styles in participants using the maps task (Förster, 2005; 2009), and test their effect on solution rates in the department store task.

Experiment

Participants. A total of 148 participants (80 female, 67 male, 1 unknown) with a mean age of 34.9 years (*SD* = 12, range = 18–64) took part in the experiment via Internet. All participants were residents of the US and had completed at least High School, 33% had a 4-year college degree in a range of different fields, the largest groups being Business (10%), Psychology (7%) and English (3%).

Materials. A 3(priming: global vs. local vs. control) x 2(task format: global vs. local) mixed design was used, with priming as the between-, and task format as the within-subjects factor. To procedurally prime participants with a processing style (global vs. local vs. control), the maps task was used (see Förster, 2005; Förster et al., 2009). For each of seven trials, participants were presented with a state map displayed on the screen. In the global condition, participants were instructed to attend to the map in its entity in order to be able to describe its overall shape in one sentence. In the local condition, participants were instructed to attend to only the respective capital marked on the screen in order to be able to describe its location in one sentence. In the control group, participants were instructed to think about an item that characterizes the respective state in order to name it in one sentence. For all three conditions, participants subsequently typed one sentence into an input field while the respective map was still presented on the screen.

To test effects of task formats, the department store task was used in a global and a local format. The local format was very similar to the original format used, thus arguably highlighting local surface features, whereas the global format was designed to highlight global structure of the problem. For both task formats, the original introductory sentence and task display depicting in- and outflows was used (see Fig.1), but the answer options *cannot be determined* were replaced with 7-point Likert scales assessing subjective confidence: How confident are you in your answer? 0 = *Not confident at all* and 7 = *very confident*. This was done to assess whether participants have a reliable feeling for correctness as a function of the task format. In the local format, participants answered the following questions:

1. During which minute did the most people enter the store?
2. During which minute did the most people leave the store?
3. During which minute were the most people in the store?
4. During which minute were the fewest people in the store?

In the global format, participants answered the following questions:

1. How are the people entering related to the people leaving the store between time periods 1 to 14? (a) More people entering than leaving (b) More people leaving than entering (c) Same amount of people entering and leaving.
2. How are the people entering related to the people leaving the store between time periods 14 to 30? (a) More people

entering than leaving (b) More people leaving than entering (c) Same amount of people entering and leaving.

3. How would you best describe the accumulation of the number of people in the store between time periods 1 to 14? (a) Increasing (b) Decreasing (c) Stable.

4. How would you best describe the accumulation of the number of people in the store between time periods 14 to 30? (a) Increasing (b) Decreasing (c) Stable.

To measure individual global-local processing styles, we used the Kimchi-Palmer-figures task (Förster & Dannenberg, 2010). Participants were presented with triangles and squares that are made up of smaller triangles and squares. Participants indicated for each of 16 trials whether a target figure (e.g., a global square made up of local squares) was more similar to a sample figure that matched its global form or its local form. Display of the figures was counterbalanced with respect to the global (local) match appearing on the left (right). Mean ratings were then conducted for each participant, ranging from 0 (completely local processing style) to 1 (completely global processing style).

Since a bi-directional link exists between good versus bad mood and a global versus local processing style (Gasper & Clore, 2002), and, in turn, mood is connected to problem-solving (Spering, Wagener & Funke, 2005), we controlled for mood effects using two 7-point Likert-scales: How do you feel right now? 0 = *Very good* and 7 = *very bad*; 0 = *Very sad* and 7 = *Very happy*.

Procedure. Participants were told that they were going to take part in two tasks, one about visual perception, and one about problem solving. Participants first completed one of three randomly assigned between-subjects procedural priming treatments (maps task): global vs. local vs. neutral. Second, participants answered both the local and the global version of the department store task, in random order. Please note that being able to answer the first version correctly (say, the global) was no prerequisite for being able to answer the second version correctly (say, the local). Third, participants completed the Kimchi-Palmer-Figures-task and, as a final set of answers, they answered the mood questions.

Results

Task format hypothesis. To test whether a global task format improves SF performance relative to a local task format, we compared solutions rates to SF tasks in both formats. For both SF questions 3 and 4, solution rates in the global format were higher than in the local task format (see Table 1). Moreover, mean confidence ratings in the local tasks were not connected to performance in the local tasks, $r = .004$, $p = .48$, but confidence ratings in the global tasks were connected to performance in the global tasks, $r = .37$, $p < .001$.

In sum, the task format hypothesis was confirmed: As expected, mean solution to the SF tasks were higher when a global relative to a local task format was used. Confidence ratings in both format might indicate, moreover, that participants are merely guessing in the local tasks, whereas they have insight into the problem structure, and therefore a reliable feeling for correctness, in the global tasks.

Table 1. *Percentage of participants who answered each of the two SF questions (questions 3 and question 4) correctly as a function of task format (global vs. local).*

Task format	Question 3	Question 4	χ^2
Local (n=148)	20%	16%	42.3***
Global (n=147)	57%	77%	109.3***

Note. Local question 3 (4): “During which minute were the most (fewest) people in the store?“. Global question 3 (4): “How would you best describe the accumulation of the number of people in the store between time periods 1 to 14 (14 to 30)?”. ***$p < .001$

Individual differences hypothesis. To test whether global-local processing styles affect SF-reasoning, processing style was correlated with mean correct solutions to all four SF tasks as a function of priming. After global priming, global-local processing styles were not connected to mean SF solution, $r(50) = -.05$, $p = .37$; processing styles were connected to mean SF solutions, however, after local and no priming, $r(99) = .21$, $p = .02$. A median split was performed to directly compare SF solutions from participants with more global vs. more local processing styles. After no priming (control), and even more so after local priming, participants with a more global processing style performed better than participants with a more local processing style (Table 2).

In sum, the individual differences hypothesis was supported: As long as global priming did not induce a global processing style anyway, participants profited from a pre-existing more global processing style when solving SF problems and achieved higher mean solutions than participants with a more local processing style.

Table 2. *Mean solution (SD) rates to all four SF tasks as a function of processing style (local vs. global) and priming (local vs. global vs. control).*

Priming	Local processing	Global processing	t
Global Priming (n=51)	.44 (.29)	.43 (.28)	-.10
Control (n=43)	.37 (.51)	.52 (.27)	-1.85*
Local Priming (n= 53)	.31 (.26)	.46 (.18)	-2.44**

Note. Local question 3 (4): “During which minute were the most (fewest) people in the store?“. Global question 3 (4):

"How would you best describe the accumulation of the number of people in the store between time periods 1 to 14 (14 to 30)?". *$p < .05$, **$p < .01$

Priming hypothesis. To test the effect of priming on solution rates to SF tasks, local and no priming conditions were collapsed, since they did not produce any significant differences in either of the four SF tasks ($p > .05$). To test differences in the number of correct solutions in SF tasks after global priming, two-sample z-tests were conducted. If participants answered the global SF tasks first, global priming had no effect on solution rates, z =1.04, p = 0.15; z =0.89, p = 0.19; z =0.46, p = 0.36 and z =0.33, p = 0.37 (for the local question 3 and 4, and the global question 3 and 4, respectively). However, if participants answered the local questions first, global priming enhanced solution rates in the local SF question compared to local or no priming for question 3 (M = 24% vs. M = 12%) and 4 (M = 18% vs. M = 7%), yielding marginal significance of z =1.44, p = 0.07 and z =0.33, p = 0.06, respectively. Global priming did not enhance solutions rates to the global tasks 3 (M = 77% vs. M = 68%) and 4 (M = 88% vs. M = 87%), yielding z =0.8, p = 0.21 and z =0.33, p = 0.23, respectively.

To control for mood-effects, we compared participants' mean mood in the three priming conditions. Results showed that participants' mood in the global priming condition (M = 5.8, SD = 1.8) was not different from the local or no priming condition (M = 6.3, SD = 1.8), $t(149) = -1.58$, $p = .12$, indicating that the effect of global priming on problem-solving performance was not simply due to mood effects.

In sum, the priming hypothesis was marginally supported: Inducing a global processing style enhanced solutions to the local, but not the global SF questions. An additional priming effect on the local SF tasks did not occur, however, if global SF tasks were answered first, indicating that answering the global SF questions first served as a prime in itself.

Discussion and Conclusion

The present experiment investigated the cognitive mechanisms underlying SF failure. We proposed global-local processing as a fundamental, cognitive explanation and tested this notion using three different approaches: Global versus local task formats, individual differences in global-local processing and procedurally priming local versus global processing. Results generally supported our notion of global-local processing to affect SF performance.

In the department store task, participants profited immensely from a global task format highlighting structural relations between the system parts compared to the original local format highlighting features of the constituent parts. Specifically, solution rates in the global format were twice (question 3) or even more than four times as high (question 4) compared to the local format. One might argue, however, that the higher solution rates in the global task format were merely due to the greater amount of information since only the global task format referred to "time periods 1 to 14" and "time periods 14 to 30", respectively. However, the global task format was specifically designed to unveil the structure of the problem, so that a greater amount of information was inherent in the design of the task format. We would even suspect, moreover, that if questions 3 and 4 left out information about time periods, the global task format would still achieve higher solution rates, simply because questions 1 and 2 already allow participants to detect the problem structure. This, however, is for further research to decide.

As a further result, there was a connection between global-local processing style and mean solutions to all SF tasks in the control group and the local priming group. Specifically, in line with our expectation, participants using overall global processing were better able to infer the overall behavior of the SF system, as measured by tasks testing an understanding of how the stock reacts to given in- and outflow progressions. Moreover, global processing could be procedurally primed in participants with the map task, resulting in (marginally significant) higher solution rates compared to local processing and the control group. This connection was only present for the local tasks, however, suggesting that participants do not profit from global processing and thus a search for structure, when the task format highlights structure in the first place. In sum, these results point towards global-local processing as a first explanation of the cognitive mechanisms involved in SF-reasoning and SF failure.

The present results contribute to an understanding of how people deal with dynamic complexity. Our results merge to the conclusion that less successful participants seem to approach the problem in a piecemeal and concrete manner, whereas successful participants seem to approach the problem in a holistic and abstract manner. Interestingly, locally processing participants tend to stick more closely to the literal information given, whereas globally processing participants tend to go beyond the given information (Friedman & Förster, 2001). With respect to SF systems, such literal use of information might result in lowest level, categorical representations (e.g., "the inflow is five"), whereas going beyond the information given might result in ordinal (e.g., "in minute 5, the inflow is smaller than the outflow") and increasingly higher-order representations (e.g., "overall, the inflow is bigger than the outflow"). Similarly, fuzzy-trace theory holds that people store two fundamentally different kinds of representations in memory: superficial verbatim representations such as exact numbers and meaning-based gist representations such as the "substance" of information (Reyna, 2012). Based on the present results, it seems plausible to speculate that, after local versus global processing of the task, participants hold fundamentally different representations of the task in memory. This, however, is for future research to decide.

In order to enhance people's ability to deal with SF systems, a range of strategies can be deduced from the present results. For example, it might be helpful to apply the principles of Gestalt psychology for pattern recognition to SF problem displays. With help of the law of good Gestalt, for example, the constituent elements of SF problems could be grouped to imply global structure and regularity. In a different vein, one could try to enable people to process dynamic problems globally, for example by teaching strategies of abstraction, pattern recognition and induction of higher-order representations. Making use of the finding that a Gestalt view is helpful for dealing with SF problems, one could even try to make computers "see" the patterns in simple SF systems in order to regulate them.

It seems interesting to speculate in how far the benefit of a global, Gestalt view applies to complex systems in general. Systems containing a range of interacting variables can hardly be regulated using analytical strategies, because of limited cognitive capacities of the problem-solver, and because information in real-life is mostly fuzzy in nature. For both reasons, form-generating Gestalt principles could be helpful: They enable the problem-solver both to conceive of the system in its most economic form and to recognize basic similarities and therefore to re-use previously successful regulation strategies. Thus, recognizing patterns in systems might enable one to recognize and use similarities in a noisy world.

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References

Booth Sweeney, L. B. & Sterman, J. D. 2000. *Bathtub dynamics: initial results of a systems thinking inventory*. System Dynamics Review 16, 249–286.

Brunstein, A., Gonzalez, C. and Kanter, S. *(2010)*, *Effects of domain experience in the stock–flow failure*. System Dynamics Review, 26(4), 347-354.

Cronin, M., & Gonzalez, C. (2007). *Understanding the building blocks of system dynamics*. System Dynamics Review, 23(1), 1–17.

Cronin, A.M., Gonzalez, C., & Sterman, D. 2009. *Why don't well-educated adults understand accumulation? A challenge to researchers, educators, and citizens*. Organizational Behavior and Human Decision Process. 108, 116-130.

Diehl, E., & Sterman, J. D. (1995). *Effects of feedback complexity on dynamic decision making*. Organizational Behavior and Human Decision Processes*, 62*(2), 198–215.

Förster, J. (2009). *Relations between perceptual and conceptual scope: How global versus local processing fits a focus on similarity versus dissimilarity*. Journal of Experimental Psychology: General, 138,88–111.

Förster, J. & Dannenberg, L. (2010). *GLOMOsys: A systems account of global versus local processing.* Psychological Inquir*y*, 21, 175–197.

Förster, J., Liberman, N.,&Friedman, R. S. (2007). *Seven principles of goal activation: A systematic approach to distinguishing goal priming from priming of non–goal constructs*. Personality and Social Psychology Review, 11, 211–233.

Friedman, R. S., & Förster, J. (2001). *The effects of promotion and prevention cues on creativity*. Journal of Personality and Social Psychology*, 81,* 1001–1013.

Friedman, R., Fishbach, A., Förster, J., & Werth, L. (2003). *Attentional priming effects on creativity*. Creativity Research Journal, 15, 277–286.

Gasper, K., & Clore, G. L. (2002). *Attending to the big picture: Mood and global versus local processing of visual information*. Psychological Science, 13, 33-39.

Gonzalez, C. & Wong, H. 2012. *Understanding stocks and flows through analogy*. System Dynamics Review, 28(1), 3-27.

Kimchi, R. (1992). *Primacy of wholistic processing and global/local paradigm*: A critical review. Psychological Bulletin, 112, 24–38.

Love, B. C., Rouder, J. N., & Wisniewski, E. J. (1999). *A structural account of global and local processing*. Cognitive Psychology, 38, 291–316.

Macrae, N. & Lewis, H. 2002. *Do I know you? Processing orientation and face recognition*. Psychological Science, 13(2), 194-196.

Navon, D. (1977). *Forest before trees: The precedence of global features in visual perception*. Cognitive Psychology, 9, 353–383.

Paich, Mark, & John D. Sterman. 1993. *Boom, bust, and failures to learn in experimental markets*. Management Science, 39(12), 1439-1458.

Reyna. 2012. *A new intuitionism: Meaning, memory and development in Fuzzy-trace Theory*. Judgment and Decision Making, 7(3), 332-359.

Schooler, J.W., Fiore, S., & Brandimonte, M. (1997). *At a loss from words: Verbal overshadowing of perceptual memories*. In D.L. Medin (Ed.), *The psychology of learning and motivation: Advances in research and theory*, (Vol. 37, pp. 291–340). San Diego, CA: Academic Press.

Schooler, J. W. (2002). *Verbalization produces a transfer inappropriate processing shift*. Applied Cognitive Psychology, 16, 989–997.

Spering, M., Wagener, D., & Funke, J. (2005). *The role of emotions in complex problem-solving*. Cognition and Emotion, 19, 1252-1261.

Sterman, J. D. (2000). *Business dynamics: Systems thinking and modeling for a complex world*. New York: McGraw-Hill.

Sterman, J. D. (2002). *All models are wrong: Reflections on becoming a systems scientist*. System Dynamics Review, 18, 501–531.

Sterman, J.D. & Booth Sweeney, L. 2002. *Cloudy Skies: Assessing public understanding of global warming*. System Dynamics Review 18, 207-240.

Tulving, E., & Schacter, D. L. (1990). *Priming and human memory systems*. Science, 247, 301–306.