Journal of Experimental Social Psychology 48 (2012) 213–219

Contents lists available at ScienceDirect

Journal of Experimental Social Psychology

journal homepage: www.elsevier.com/locate/jesp

Social audiences can disrupt learning by teaching☆,☆☆

Jonathan S. Herberg *, Daniel T. Levin, Megan M. Saylor

Vanderbilt University, USA

A R T I C L E I N F O

Article history:
Received 19 January 2011
Revised 1 July 2011
Available online 19 July 2011

Keywords:
Social cognition
Social facilitation
Learning-by-teaching

A B S T R A C T

To investigate the effect of a social audience on learning-by-teaching, we examined participants' solutions of the 4-ring Tower of Hanoi problem after they demonstrated the 3-ring problem to a social agent (a person) or a non-social agent (a computer). In Experiments 1 and 2 participants produced less optimal solutions of the 4-ring problem after demonstrating the 3-ring problem to a social agent. An analysis of pointing behavior demonstrated that social highlighting contributed substantially to this effect. Together, these findings indicate that more social highlighting may produce a cost, rather than a benefit, on how deeply the demonstrator encodes the problem solution. Experiment 3 clarified that these results were not simply caused by the disruptions inherent to social highlighting. Taken together, the results suggest that social highlighting does not come for free — producing the highlighting may lead to more shallow encoding of demonstrated actions.

Introduction

Research on human learning has shown that simple models of learning as a unidirectional transfer of information from teacher to learner are inadequate (Topping, 2005). Rather, in a wide array of learning interactions, deep learning of complex topics and problems is driven not just by actions by the tutor, but also by the tutee, and by the social interactions that support constructive knowledge-building (Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001; Roscoe & Chi, 2007). A particularly important example of the constructive nature of learning is learning-by-teaching, in which teaching another person facilitates the tutor's understanding, sometimes even more than trying to learn the material for oneself (Roscoe & Chi, 2007). Enhanced benefits from learning-by-teaching have been shown in domains ranging from reading skills (e.g., Juel, 1996) to math and science concepts (e.g., Topping, Campbell, Douglas, & Smith, 2003; Topping, Peter, Stephen, & Whale, 2004).

On one view, the benefits of learning by teaching may derive from the default social response to the mere presence of an audience. Not only can an audience produce basic social facilitation that heightens attention and arousal (Bargh, 1994; Guerin, 1986; Zajonc, 1965), but the presence of social actors can activate non-egocentric perspective taking and simulation of actions (Castiello, 2003; Iacoboni, 2009; Levine, Resnick, & Higgins, 1993). Even the mere suggestion that social actors will later be exposed to persuasive statements produced by the subject can increase subjects' attitude change (Nel, Helmreich, & Aronson, 1969; Wicklund & Duval, 1971; Wood, 2000). More to the point, research has previously shown that demonstrating simple tasks to an imagined social audience (represented by a picture of a person) produces a range of social responses, including social highlighting behaviors (such as pointing to task-relevant goals) that do not occur for a nonsocial audience (a computer; Herberg, Saylor, Ratanaswasd, Levin, & Wilkes, 2008).

However, other research and theory suggest that learning-by-teaching benefits require a deeper interaction with the audience that promotes metacognition (e.g., Aleven & Koedinger, 2002; VanLehn, Siler, Murray, Yamauchi, & Baggett, 2003; Wagster, Tan, Wu, Biswas, & Schwartz, 2007) and knowledge-building (Roscoe & Chi, 2007). On this view, benefits from learning by teaching do not occur (or at least are not maximized) by the mere presence of social audience, but rather are a product either of extensive pre-teaching preparation (e.g., Bargh & Schul, 1980; Benware & Deci, 1984), or of subsequent interactions with the audience (e.g., Chi, 2009).

Based on the research reviewed above, it appears that benefits from learning by teaching may stem from the simple presence of a social audience, or they may require extensive interaction and/or explicit consideration of the knowledge of the tutee. Understanding the factors that produce benefits from social audiences is particularly important because social audiences may invoke costs as well, and if these costs are borne in the absence of benefits, it becomes possible that social audiences may actually *interfere* with learning by teaching. Research on theory of mind suggests that many of the basic processes required to determine that another person's knowledge differs from one's own are resource-intensive (Apperly, Riggs, Simpson, Chiavarino, & Samson, 2006; Epley, Boven, Keysar, & Gilovich, 2004; Leslie, Friedman, & German, 2004). Although adults may not always pay these costs because they sometimes treat agents in a shallow

☆ We would like to thank Bethany Rittle-Johnson for reading and commenting on a previous version of this manuscript.

☆☆ This material is based upon work supported by the National Science Foundation under grant no. 0433653 to DTL and MMS.

* Corresponding author at: Department of Psychology and Human Development Vanderbilt University 230 Appleton Place Nashville, TN 37203, USA. Fax: +1 615 343 9494.
E-mail address: jonathan.s.herberg@vanderbilt.edu (J.S. Herberg).

0022-1031/$ – see front matter © 2011 Elsevier Inc. All rights reserved.
doi:10.1016/j.jesp.2011.07.004

manner (e.g., Barr & Keysar, 2005), there are clearly many situations where adults do engage deeper cognitions, and would therefore be expected to experience these cognitive costs (e.g., Csibra & Gergely, 2007). The resource-intensive nature of theory of mind reasoning, combined with the possibility that this resource expenditure will not improve learning, makes it critical to test what happens when one needs to focus enough attention on an agent's knowledge states to teach the agent something, but there is no opportunity for deeper interaction. If learning-by-teaching can produce benefits in the absence of the explicitly constructive reasoning that comes from deep interactions with the learner, we would expect benefits to be exhibited in such a situation. Alternatively, if social processing costs sometimes overwhelm social benefits of learning by teaching, it is possible that teaching a social other will *lessen* learning.

Experiment 1

Two conditions tested whether the initial cognitive responses induced by an agent improve, or possibly interfere with, learning by teaching. We employed a design partly based on research establishing social effects from the mere presence of a passive audience (Guerin, 1986; Zajonc & Sales, 1966) and similar to that used in Herberg et al. (2008) in which participants taught a human or a computer (represented by a simple picture) to solve the Tower of Hanoi problem. Thus, our goal was to test the degree to which the mere presence of a social audience would affect learning, independent of any actual interaction with that audience. The Tower of Hanoi puzzle involves three poles and three or more rings of different sizes. The rings start on the leftmost pole and the goal is to get them to the rightmost pole. The constraints are that one is allowed to move only one ring from the top of any pole to another pole at a time, and that one is not allowed to place a larger ring on top of a smaller ring. In the current experiment, participants first learned to solve the 3-ring Tower of Hanoi problem, then demonstrated their solution to a computer or human agent. Finally, they solved the more difficult 4-ring Tower of Hanoi problem for themselves, in the absence of the agent. The idea was to measure how deeply they learned from their demonstration of the 3-ring problem by examining how effectively they generalized to the 4-ring problem.

Method

Participants

56 Vanderbilt undergraduates and members of the surrounding community participated for class credit or $10. Six were excluded from analysis for having prior experience solving Tower of Hanoi problems (2 from the Human condition and 4 from the Computer condition), 4 for violating task rules (1 from the Human condition and 3 from the Computer condition), and 2 for failing to solve the 4-ring task within 6 min (both from the Human condition). Therefore, the data for 44 participants (22 in each condition, alternately assigned) were analyzed (Mean age = 26.4 years, 25 females).

Materials

For the Human condition, participants saw a picture of a college-aged male. For the Computer condition, a picture of a computer and monitor with a mounted camera was used. Participants were also shown a picture of a mechanical device capable of grasping objects when the computer audience was described, though this picture was not present when participants demonstrated their solution.

The materials participants used to solve the Tower of Hanoi tasks were three plastic tubes and three or four plastic rings (a small red ring, medium sized yellow ring, and large green ring for the 3-ring problem, plus a larger blue ring for the 4-ring problem). Participants' solutions and demonstrations were videotaped for later coding.

Procedure

Three plastic poles with three rings on the leftmost pole were placed on a table in front of the participant. Participants were told that the goal of the task was to get the three rings from the leftmost pole to the rightmost pole. They were told that they could move one ring at a time from one pole to any other pole, and that they could not move a larger ring on top of a smaller ring.

After explaining the three-ring Tower of Hanoi task, the experimenter asked the participant to complete the task, then went behind a curtain to avoid influencing the participant's solutions and demonstrations. When the participant indicated he or she had finished the task, the experimenter re-entered the room and set up the materials for demonstrating it. A picture of the audience (human or computer) was placed on a stand to the participant's front and right, as well as the three rings and three poles in their original setup. The experimenter described the audience the participant was going to demonstrate to. The human audience was described as being ready to learn the Tower of Hanoi task by watching the participant. The computer audience was described as being able to take in action information through a camera and to carry out actions by moving a mechanical gripping device. In both cases participants were instructed to imagine the computer or human audience in the room while they demonstrated the task in whatever way they felt natural to allow the audience to be able to do the same action. Participants were told not to use language. After describing the audience and explaining the demonstration task, the experimenter again left the participant's section of the room. After the participant indicated he or she had finished the demonstration of the 3-ring Tower of Hanoi problem, the experimenter set up the 4-ring Tower of Hanoi problem with the same three rings as before, plus one larger ring on the bottom. Participants were told that that their task was to solve a more difficult version of the same problem, with the same rules, constraints, and goal, but with four instead of three rings. The audience was removed, and participants were told to simply solve the problem and not worry about the audience anymore. The experimenter then left the participant alone to solve the problem. If the participant failed to solve the problem in 6 min, the experimenter ended the session (excluding the participant's data from analysis).

Coding

Videos of participants' solutions to the Tower of Hanoi problems were coded for solution time and the number of solution steps (movements of a ring from one pole to another). If a step was undone the initial movement was not counted as a step. Both shorter solution times and fewer steps indicate a better understanding of how to solve the task (e.g., Goel & Grafman, 1995). If the participant restarted the task then the number of steps only in the final, complete solution was counted. For all experiments, all statistically significant findings remain when participants who restarted the 4-ring task are excluded from analysis.

Additionally, in participants' demonstrations of the 3-ring solution, the number of looks at the picture of the audience, and the number of gestures highlighting objects and actions (usually points) were counted, to measure participants' social response behaviors. This was done both as a manipulation check and to test whether different kinds of social behaviors may impact participants' learning in different ways. There may be mere-presence effects on learning-by-teaching, which may be captured best by investigating participants' looking frequency at the audience. There may also be different effects from the more effortful reasoning one undertakes in engaging in social highlighting behaviors, which can be ascertained by looking at how frequently participants point in their demonstrations.

A preliminary check was made to ensure there were no mean differences in Tower of Hanoi problem solving abilities in participants in the Computer vs. Human conditions. Participants in the Computer vs. Human conditions did not reliably differ in either variable in the 3-