Army Research Laboratory

The Impact of Need for Cognition and Self-Reference on Tutoring a Deductive Reasoning Skill

by Anne M. Sinatra, Valerie K. Sims, and Robert A. Sottilare

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Aberdeen Proving Ground, MD 21005

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14. ABSTRACT
Individual differences in the Need for Cognition (NFC) have been demonstrated to impact academic achievement, problem solving, and many classic psychology effects. The Self-Reference Effect (SRE) has been consistently shown to assist in recall and has been applied in education through context personalization of learning material. The current study examined if the SRE could aid learning for an applied deductive reasoning skill (completing a logic grid puzzle), and if an individual's NFC would impact learning outcomes. There were 134 participants that interacted with a computer-based tutoring system to teach them how to solve logic grid puzzles. In a logic grid puzzle, an individual uses deductive reasoning, and a set of clues to determine correct and incorrect information. During the tutorial, the puzzle and clues that the participants learned with either included their own name and the names of two close friends (self-reference), the names of three characters from the *Harry Potter* series, or names that were not expected to belong to the participants in the study. The names present in the tutorial interacted with NFC, so that those who were in the self-reference condition who were low NFC scored significantly lower on transfer performance than those that were high NFC. This suggests that individuals with high and low NFC may be impacted differently by self-reference, and it is important to consider its inclusion in instruction.

15. SUBJECT TERMS
self-reference effect, need for cognition, context personalization, deductive reasoning, tutoring, cognitive psychology

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1. Introduction

1.1 The Impact of Need for Cognition (NFC) and Self-Reference on Tutoring a Deductive Reasoning Skill

The NFC is a bit of a mystery. It is a personality related trait that has been defined as an individual's enjoyment of thinking and cognitive tasks (Cacioppo and Petty, 1982). Cacioppo and Petty (1982) developed a scale to measure the NFC, which has been consistently used in studies to break participants into high and low NFC groups (Cacioppo and Petty, 1982; Cacioppo et al., 1996; Cacioppo et al., 1984). The impact of one's NFC has been examined in a number of classic psychology effects such as anchoring, false memories, halo effects, and priming (Epley and Gilovich, 2006; Graham, 2007; Perlini and Hansen, 2001; Petty et al., 2009; Petty et al., 2008). There are often differences found in individuals with high and low NFC on these effects and even in cases when they have similar reactions it may be due to different mechanisms. In some cases, those who are high in NFC are more susceptible to bias, as they spend more time thinking about information than those who are low NFC (Petty et al., 2009). Interestingly, concepts that would be expected to be theoretically related to NFC, such as working memory span have found to be unrelated (Hill et al., 2012). NFC has been found to be related to academic achievement (Cacioppo et al.,1996; Dwyer, 2008), and problem solving ability (Coutinho et al., 2005; Nair and Ramnarayan, 2000), with those high in NFC generally performing better in these areas than those who are low NFC. Those who are high in NFC tend to take more time evaluating messages and are more concerned with argument quality than those with low NFC (Cacioppo et al., 1983).

Those who are high in NFC tend to think more about information, which ultimately results in differences in the ways that they react to presented information (Petty et al., 2009). While differences between those who are high and low in NFC have been found in a number of classic psychology effects, the impact of NFC on the Self-Reference Effect (SRE) has not yet been examined. The SRE is the ability to increase recall when an individual relates information to him or herself. The SRE has been replicated numerous times, and may have a positive impact on learning and retention (Symons and Johnson, 1997). As those with high NFC enjoy thinking, and interact with/judge information in a different way than those with low NFC, it may lead to differences in the effectiveness of the SRE as a learning tool for individuals with these characteristics.

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1.2 The SRE and Context Personalization

The primary means in which the SRE has been examined is the depth of processing (DOP) paradigm, in which participants look at a displayed word and are asked a question about it such as judging a physical characteristic of a word or the meaning of it (Craik and Tulving, 1975). It has consistently been found that words that the participant thinks about in relationship to the self are recalled better than words that are simply examined for meaning (Rogers et al., 1977; Symons and Johnson, 1997). A similar, yet not as strong effect has been found for relating information to individuals that one knows well and has an elaborate knowledge of, such as his or her own mother (Symons and Johnson, 1997). Additionally, people who are familiar to the individual (e.g., friends) and fictional characters, such as *Harry Potter* have been demonstrated to also provide some benefits toward memory when normal individuals are asked to judge if a word is true of the individual (Lombardo et al., 2007; Henderson et al., 2009). The SRE has also been found to be beneficial in more applied situations, such as recalling details from a paragraph (Reeder et al., 1987), and remembering items that individuals are told to pretend are their own (Cunningham et al., 2008).

The SRE has been applied to education through context personalization, which can be described as adapting a lesson or instruction of a skill to include information that is specific to the individual learner. It has been found that by including names (the self, a friend) and things that are of interest to individuals in math word problem examples it can assist in a learner's ability to apply what they learned to new problems (Anand and Ross, 1987; Ku and Sullivan, 2002). This approach includes not only giving context to the problem and grounding it in something that is real-world and understandable by the student but also using examples that they find inherently interesting. The personalization of examples to contexts that an individual is highly familiar with (such as their major) also can provide learning benefits (Ross, 1983; Ross et al., 1986). Simply including the word "you" within the word math problems to be learned can improve performance, as it encourages the individual to think of themselves, and likely activates the SRE (d'Ailly et al., 1997; Moreno and Mayer, 2000). While it has been shown that the SRE and context personalization does not always provide benefits for simple assessments of the learned material, it does provide a significant benefit to transfer performance, and using the material in a new way (Moreno and Mayer, 2000). This suggests that the SRE may be promoting "deep learning," which allows the individual to make additional connections and have a better understanding of the material (Chow, 2010).

Both an individual's own name (Moray, 1959; Wood and Cowan, 1995), and the name of popular characters from the *Harry Potter* series (Sinatra et al., 2011; Sinatra et al., 2012) have been shown to be powerful and important enough to an individual to break into attention when one is actively engaged in a difficult task. By asking an individual to read and think of material that includes their own name, and/or familiar characters, the included names may provide a context, or schema, for individuals to link the material to while they are learning it. Characters from the *Harry Potter* series may be particularly helpful in creating a context, as many students in the current population of college-age students grew up reading the books. *Harry Potter* has consistently been reported to be one of the top book series read for fun by school-age children ("Kids and Family Reading Report–Online Press Kit: Scholastic Media Room," 2013). Further, it has been suggested that repeated viewing of the *Harry Potter* films can lead to further engagement and identification with the characters (Finch, 2012). As the film series grossed 2.39 billion dollars in the U.S. and 7.72 billion dollars world-wide ("Harry Potter Movies at the Box Office," 2013), it is very likely that even if an individual is not a fan of the series, they are familiar with it. The familiarity with the characters may result in a milder version of the SRE consistent with the finding that linking information to one's mother can improve retention.

1.3. Deductive Reasoning

Deductive reasoning is a useful skill and process that can be defined in the words of the classic literary character Sherlock Holmes, "When you have eliminated the impossible, whatever remains, however improbable, must be the truth" (Doyle, 1890). It has been shown that individuals are not inherently good at abstract deductive reasoning tasks (Wason and Shapiro, 1971), but if given a contextualized and familiar example, performance is improved (Cheng et al., 1986). Deductive reasoning can be taught and practiced through completing logic grid puzzles. In a logic grid puzzle, an individual uses a set of clues to narrow down correct and incorrect information. Based on these clues, they can then deduce the correct answers. It has been recommended that these puzzles be used in a language learning classroom, as they require individuals to think and reason at a deep level, which can lead to learning gains (McDonald, 2007). Deductive reasoning is a highly transferable skill that is applicable in many different educational domains. As these puzzles often include names in them, there is an opportunity to examine the SRE by including the names of familiar individuals within the puzzles.

2. The Current Study

The current study examines if the SRE is moderated by NFC in a tutoring/learning acquisition environment. The information gained from this study can have important implications for the application of the SRE in education. Participants learned how to solve logic grid puzzles by working through an interactive tutorial. Within the tutorial, the names that were present in the puzzle and clues varied depending on the condition. There were three conditions, which had different names in them: (1) Self-Reference (own name and names of friends), (2) Popular Culture (names of *Harry Potter* characters), and (3) Generic (names expected not to belong to the participant). Overall, it was expected that the material in the Self-Reference and Popular Culture conditions would be more deeply learned than the Generic condition and result in better learning outcomes. However, an individual's initial experience with the task, or skill level, (determined through a pre-test score), and NFC are expected to moderate the benefits of the conditions. Performance was examined in a hierarchy from "shallow" to "deep" learning.

Participants were given content questions to assess what they learned from the material, applied clue questions to examine their ability to apply the information they learned, an easy puzzle to assess their ability to perform the task, and a difficult puzzle to assess their transfer performance. It was expected that the differences between conditions would be largest in the case of the more applied transfer performance (the difficult puzzle).

According to the Cognitive Theory of Multimedia Learning (Mayer, 2005), individuals have dual channels for processing (visual and verbal); these channels have a limited capacity for processing, and learning involves a number of different active cognitive processes. Additionally, after information is brought into working memory, prior knowledge from long-term memory is activated to assist in connecting, storing, and structuring the learned material (Mayer, 2005; Mayer and Moreno, 2003). By including an individual's name or a popular culture name in the training materials, the benefits may be two-fold: (1) easier retention and recall due to the SRE, and (2) reducing cognitive load by linking information to previously stored information about the self or the character, resulting in deeper learning. Those who already have a high-skill level in deductive reasoning may initially have a reduced cognitive workload in comparison to those who are low-skill level, which would result in the SRE impacting their learning differently. Further, those who are high NFC may be practiced at relating information to themselves, which could reduce their cognitive workload, resulting in more learning than those who are low NFC.

The names that are included within the tutorial's puzzles are provided to activate a schema for the self or fictional characters, which can then be linked to the learned material. This information can additionally be described by Mayer and Moreno (2003) as incidental information, which is interesting, but not vital to the understanding of the concept. They suggest that by removing incidental information, cognitive load is reduced and individuals can retain more information and learn more deeply. However, context personalization research suggests that by including details and examples that are consistent with an individual's interests it actually can assist learning and potentially reduce cognitive workload (Anand and Ross, 1987; Ku and Sullivan, 2002). It is expected that rather than adding to cognitive workload, this incidental information will prompt the individual to link information to themselves, or the fictional characters in *Harry Potter*, which would benefit from the SRE, and an already existing schema in long-term memory, thus reducing cognitive workload.

It is possible that one's NFC level (high or low) and initial skill level in the area of deductive reasoning (high or low) will impact their learning outcomes, so that those who are high in these characteristics will benefit from a more reduced cognitive load than those who are low in the characteristics. Therefore, the current study examines three possible theory supported hypotheses: (1) self-reference will reduce cognitive load for all individuals, and assist in learning the material; (2) self-reference will be more beneficial for those with high NFC than low NFC, as the cognitive load will be reduced for the high NFC individuals who are already practiced in thinking and relating information to previous concepts; and (3) self-reference will be more beneficial to those with initial high-skill level than low, as their previous knowledge is reducing cognitive workload.

3. Method

3.1 Participants

There were 138 participants recruited from the extra credit pool at a large southeastern metropolitan university. Four participants were removed from the sample before analysis due to equipment problems (2), non-completion (1), and working on paper (1). Of the final sample of 134 participants, there were 81 females (60.4%) and 53 males (39.6%). Participant ages ranged from 18 to 31 years (M = 19.64 years, SD = 1.990 year)[*]. An initial power analysis prior to data collection with *G*Power 3* indicated that 111 participants would be necessary to have a power of 0.8 with an expected medium effect size (Faul et al., 2007).

The participants were randomly assigned to one of three conditions: Self-Reference (M = 19.58 years, SD = 2.039 years; N = 45), Popular Culture (M = 19.53 years, SD = 2.292 years; N = 45), and Generic (M = 19.82, SD = 1.603; N = 44). All conditions were similar in their percentage of males (40%) and females (60%). The sample was divided into groups of those with high- and low-skill levels based on a median split of the pre-test scores. There were 80 high-skill participants (59.7%), and 54 low-skill participants (40.3%).

The sample was also divided into those who scored high and low on the 18-item NFC scale (Cacioppo et al., 1984). Sixty-nine participants were considered high NFC (51.5%), and 65 participants were considered low NFC (48.5%).

3.2 Design

The study employed a 3 (condition) × 2 (high or low skill) × 2 (high or low NFC) between subjects design. There were three conditions, Self-Reference, Popular Culture, and Generic, which participants were randomly assigned to upon arriving for the study. The dependent variables (DVs) included performance measures (content questions, applied clue questions, logic puzzles, time in the tutorial), and self-report ratings about the tutorial (ease, enjoyment, learning).

[*] *M* is Means; *SD* is Standard Deviation.

3.3 Materials and Apparatus

Logic grid puzzle tutor. A computer-based logic grid puzzle tutor was created using PowerPoint 2007 and Visual Basic for Applications (VBA). Participants were walked through solving a puzzle, and were taught about six different types of clues that are common to logic grid puzzles (e.g., True Relationship, False Relationship, Either/Or). Participants were presented with an explanation of the clue type and then prompted to enter the information provided from the clue into a grid. If participants entered the wrong answer into the grid, the program told them that it was incorrect and prompted them to enter the correct answer by providing feedback in a popup box (e.g., “You have the right cell, but the wrong letter. Put an X in this cell”). Participants were unable to move on from a slide until they had successfully completed the task that they were instructed to do. Once all the clues were completed, the participants were walked through how to use deductive reasoning to fill in the rest of the grid to solve the puzzle.

There were three slightly different versions of the tutorial, which varied based on the condition, and requested that different names be typed into a series of popup boxes. At the beginning of the tutorial, those in the Self-Reference condition were asked to type in their own name and the names of two close friends. In the Popular Culture condition, participants were asked to type in the names “Harry,” “Ron,” and “Hermione.” In the Generic condition, participants were asked to type in the names “Colby,” “Russell,” and “Denise.” The names were each saved as separate variables and were read into the program to personalize it for the participant. The names were present within the clues, puzzle grid, story that setup the puzzle, and in the directions the participants received.

The Generic names were selected by selecting the average birth year that was expected of the participants (1993), and then choosing names that were only moderately popular as birth names in the United States of America from that year (Social Security Online. Popular Baby Names.). None of the participants indicated that their first or last names were the ones used in the Generic condition.

The underlying logic of the tutorial was designed to be consistent with the puzzle in the introduction of the logic grid puzzle book “Puzzle Baron’s Logic Puzzles” (Puzzle Baron’s Logic Puzzles, pp. iii–ix, 2010), which introduces different types of clues and a practice puzzle. A neutral topic (ordering food at a bakery) was chosen for the puzzle to avoid referencing information that might be true or false about the participants. The puzzle consisted of six clues (one of each type), and a story that explained that three friends (the entered names) ordered three different baked goods (brownie, cake, cookie) which had one of three different color sprinkles (green, purple, yellow). The participant was tasked to use the grid and clues to determine which individual ordered which baked goods and which color sprinkles it had. There were 27 cells on the grid with nine representing positive relationships (“O”) and 18 representing negative relationships (“X”). The program recorded the timestamp of the time that the participant began the tutorial, and the time that the participant ended the tutorial. See figure 1 for a side by side comparison of the same clue presented in the Popular Culture and Generic conditions.

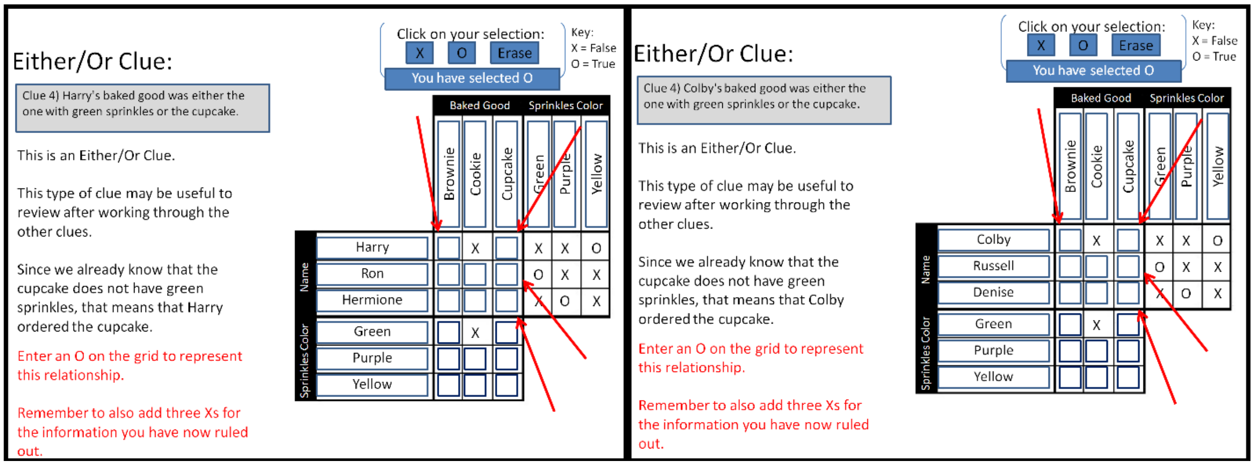

Figure 1. Screenshots of the same clue in the Popular Culture (left) and Generic (right) conditions. The names within the grid, clue and instructions are different.

Applied clue questions. A series of applied clue questions were created for the pre-test (six questions), and as an assessment after the tutorial (12 questions). The questions assess an individual’s understanding of how to apply deductive reasoning to understanding clues. They required individuals to read a brief story, a clue, and then check all the possible conclusions that could be drawn based on the clue.

Easy and difficult logic grid puzzle assessments. Two computer-based logic grid puzzles (easy and difficult) were created in PowerPoint using VBA. The puzzles themselves did not include any names, as to not interfere with the names that were present in the tutorial. The easy puzzle was at the same difficulty level as the puzzle in the tutorial. It had five clues, and 27 spaces on the grid. Participants had to match three beverages with three meals and three desserts that were ordered together. The difficult puzzle was more complex than the one in the tutorial, and was intended to measure transfer performance. It had seven clues, and 72 spaces on the grid. Participants had to match five car types with five colors and five years that they were made. For both puzzles, participants were told that once it began they would have 10 minutes (min) to complete the grid and submit it on their own or it would move on by itself. Once the puzzle was submitted (either by the individual or automatically) the letters that were put into the grid were saved into a spreadsheet. See figure 2 for a screenshot of both logic puzzle assessments.

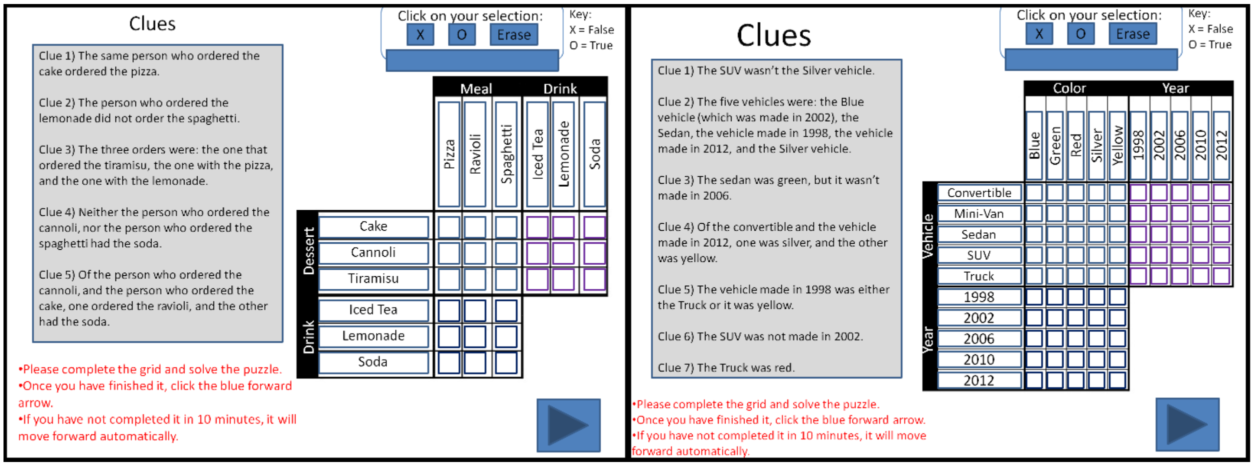

Figure 2. Screenshots of the easy (left) and difficult (right) logic puzzle assessments.

Computer. The experiment was run on three identical Dell Latitude E6410 laptop computers, with a resolution of 1280 × 800 pixels. Each computer used Microsoft PowerPoint 2007 and the Generalized Intelligent Framework for Tutoring (GIFT) version 2.5 to run the experiment.

GIFT. The GIFT is an open source program developed by the U.S. Army Research Laboratory (ARL) to create intelligent tutoring systems (Sottilare et al., 2012). GIFT 2.5 was used in the current study to create and administer surveys, to provide instructions to participants, and to transition between programs.

NFC scale. The current study used the 18-item version of the NFC scale (Cacioppo et al., 1984). The scale asks individuals to respond to a series of items related to thinking (e.g., "I prefer complex to simple problems.") and to indicate how characteristic or uncharacteristic they feel the statement is of them. According to Cacioppo et al. (1984), the scale had a cronbach alpha (internal consistency) of 0.90. In the current study, the cronbach alpha was 0.917.

3.4 Procedure

Participants signed up for the study through the university's online system and received extra credit. Participants were run through the study in groups of three and could view only their own computer screen. Each participant was given an informed consent form and the opportunity to ask any questions that he or she had. After the experimenter set up the GIFT program on the participant's computer for the appropriate randomly assigned condition, the experiment ran on its own with transitions occurring through the software (e.g., opening and closing PowerPoint).

Participants completed the pre-test and then engaged in the logic grid puzzle tutorial. The participant was instructed to enter the appropriate names for the condition that he or she was in. The names were then saved as variables and read into the PowerPoint file throughout the tutorial. In order to complete the tutorial, individuals needed to correctly respond to all of the instructions that were given to them. Therefore, the amount of time spent in the tutorial is a measure of how good the participant was at the task and how long it took them to complete it.

Participants then were asked to rate their feelings about the tutorial (e.g., easy, enjoyable). They then completed 20 multiple choice and true/false questions about the content of the tutorial, and 12 applied clue questions (two for each type of clue in the tutorial). Then participants were given 10 min to complete an easy puzzle, similar to the one in the tutorial, and an additional 10 min for a difficult logic grid puzzle, which was more complicated and challenging than the one in the tutorial. The goal of the difficult puzzle was to examine transfer performance and the ability to perform the skill in a more difficult situation.

Participants then completed a series of demographic questions (including a questionnaire about their familiarity with the *Harry Potter* series). The participants were individually given debriefing forms and an opportunity to ask any questions that he or she had.

3.5 Grading

Percentages were calculated for the number of correct content questions and the number of correct applied clue questions. Each individual logic puzzle was graded for percentage of correct answers entered onto the grid. The time spent in the tutorial was calculated as a measure of performance.

4. Results

A series of three (condition) × 2 (high or low skill) × 2 (high or low NFC) ANOVAs were run for the dependent variables of percentages correct of content questions, applied clue questions, the easy puzzle, the difficult puzzle, and time spent in the tutorial using SPSS 19.0. Significant main effects will be discussed, and all main effect *F*-Tests are in table 1.

Table 1. Main effect *F*-Test for each assessment.

Assessment	Test	*F*-Test	ηp^2	p-value
Content	Condition	$F(2, 122) = 0.451$	0.007	0.638
	NFC	$F(1, 122) = 15.140$	0.110	<0.001*
	Skill Level	$F(1, 122) = 6.516$	0.051	0.012*
Applied Clue	Condition	$F(2, 122) = 0.859$	0.014	0.436
	NFC	$F(1, 122) = 11.532$	0.086	0.001*
	Skill Level	$F(1,22) = 17.090$	0.123	<0.001*
Easy Puzzle	Condition	$F(2, 122) = 0.676$	0.011	0.511
	NFC	$F(1, 122) = 10.159$	0.077	0.002*
	Skill Level	$F(1, 122) = 9.738$	0.074	0.002*
Difficult Puzzle	Condition	$F(2, 122) = 0.559$	0.009	0.573
	NFC	$F(1, 122) = 9.424$	0.072	0.003*
	Skill Level	$F(1,122) = 7.689$	0.059	0.006*
Time in Tutorial	Condition	$F(2, 122) = 0.605$	<0.001	0.547
	NFC	$F(1, 122) = 0.014$	0.010	0.905
	Skill Level	$F(1,122) = 0.020$	<0.001	0.887

*Indicates a significant difference.

4.1 Content Questions

Those who had higher NFC scores (M = 95.58%, SD = 7.403%) scored significantly higher on the content questions, than those with lower NFC scores (M = 90.00%, SD = 9.270%), $F(1, 122) = 15.140$, $p<0.001$, $\eta p^2 = 0.110$. Those who were high skill (M = 94.79%, SD = 7.71%) scored significantly higher on the content questions than those who were low skill (M = 90.96%, SD = 9.49%), $F(1, 122) = 6.516$, $p = 0.012$, $\eta p^2 = 0.051$.

There was a significant interaction between NFC and skill level, $F(1, 122) = 8.272$, $p = 0.005$, $\eta p^2 = 0.063$. To investigate this interaction, individual independent samples t-tests were run for each skill group. For low-skill level, those with low-NFC scores (M = 86.32%, SD = 9.948%) scored significantly lower than those with high NFC scores (M = 96.00%, SD = 4.168%), $t(48.181) = 4.978$, $p<0.001$. For high-skill level, those with low NFC (M = 94.023%, SD = 6.509%) were not significantly different than those with high NFC (M = 95.408%, SD = 8.406%), $t(78) = 0.775$, $p = 0.440$.

4.2 Applied Clue Questions

Those with low NFC (*M* = 71.79%, *SD* = 25.841%) scored significantly lower on applied clue questions than those with high NFC (*M* = 85.27%, *SD* = 14.319%), $F(1, 122) = 11.532$, $p = 0.001$, $\eta p^2 = 0.086$. Those that were low-skill level (*M* = 68.056%, *SD* = 25.685%) scored significantly lower on the applied clue questions than those with high-skill level (*M* = 85.94%, *SD* = 14.919%), $F(1,22) = 17.090$, $p < 0.001$, $\eta p^2 = 0.123$.

4.3 Easy Puzzle Performance

Those with low NFC (*M* = 83.76%, *SD* = 26.431%) scored significantly lower on the easy puzzle than those with high NFC (*M* = 95.81%, *SD* = 12.315%), $F(1, 122) = 10.159$, $p = 0.002$, $\eta p^2 = 0.077$. Those who were low-skill level (*M* = 81.62%, *SD* = 27.178%) scored significantly lower on the easy puzzle than those who were high-skill level (*M* = 95.60%, *SD* = 13.517%), $F(1, 122) = 9.738$, $p = 0.002$, $\eta p^2 = 0.074$.

4.4 Difficult Puzzle Performance

Those with low NFC (*M* = 63.84%, *SD* = 23.783%) scored significantly lower on the difficult puzzle than those with high NFC (*M* = 78.13%, *SD* = 20.118%), $F(1, 122) = 9.424$, $p = 0.003$, $\eta p^2 = 0.072$. Those who were low-skill level (*M* = 63.68%, *SD* = 24.073%) scored significantly lower on the difficult puzzle than those who were high-skill level (*M* = 76.27%, *SD* = 20.969%), $F(1,122) = 7.689$, $p = 0.006$, $\eta p^2 = 0.059$.

There was an interaction of NFC and condition for the difficult puzzle, $F(2, 122) = 4.277$, $p = 0.016$, $\eta p^2 = 0.066$. See table 2 for the Means (*M*) and Standard Deviations (*SD*) for those in the low and high-NFC conditions separated by condition.

Table 2. Percentages correct for the difficult puzzle for the condition x NFC interaction.

	Low NFC	**High NFC**
Condition	***M (SD)***	***M (SD)***
Self-Reference	52.98% (17.123%)	80.26% (22.174%)
Popular Culture	71.11% (24.012%)	78.03% (17.83%)
Generic	65.27% (25.915%)	75.69% (20.263%)

In order to examine the interaction, a series of post-hoc independent samples t-tests were run. For the self-reference condition, those with high NFC (*M* = 80.26%, *SD* = 22.174%) scored significantly higher than those with low NFC (*M* = 52.98%, *SD* = 17.132%), $t(43) = 4.470$, $p < 0.001$. For the popular culture condition, there were no significant differences between the scores of those with high NFC (*M* = 78.031%, *SD* = 17.832%) and low NFC (*M* = 71.11%, *SD* = 24.012%), $t(43) = 1.084$, $p = 0.284$. For the generic condition, there were no significant differences between the scores of those with low NFC (*M* = 65.37%, *SD* = 25.915%) and high NFC (*M* = 75.69%, *SD* = 20.263%), $t(42) = 1.486$, $p = 0.145$.

For those with low NFC, those in the self-reference condition scored significantly lower than those in the popular culture condition, $t(41) = 2.776$, $p = 0.008$, but not the generic condition, $t(39) = 1.760$, $p = 0.086$. For low NFC, there was no significant difference between the scores of those in the popular culture and generic conditions, $t(44) = 0.793$, $p = 0.216$.

For those with high NFC, there were no significant differences between the self-reference condition, the popular culture condition, $t(45) = 0.372$, $p = 0.711$, or the generic condition, $t(46) = 0.738$, $p = 0.464$. Further, for high NFC, there was no significant difference between the popular culture and generic conditions, $t(44) = 0.793$, $p = 0.432$. See figure 3 for a visual representation of this interaction.

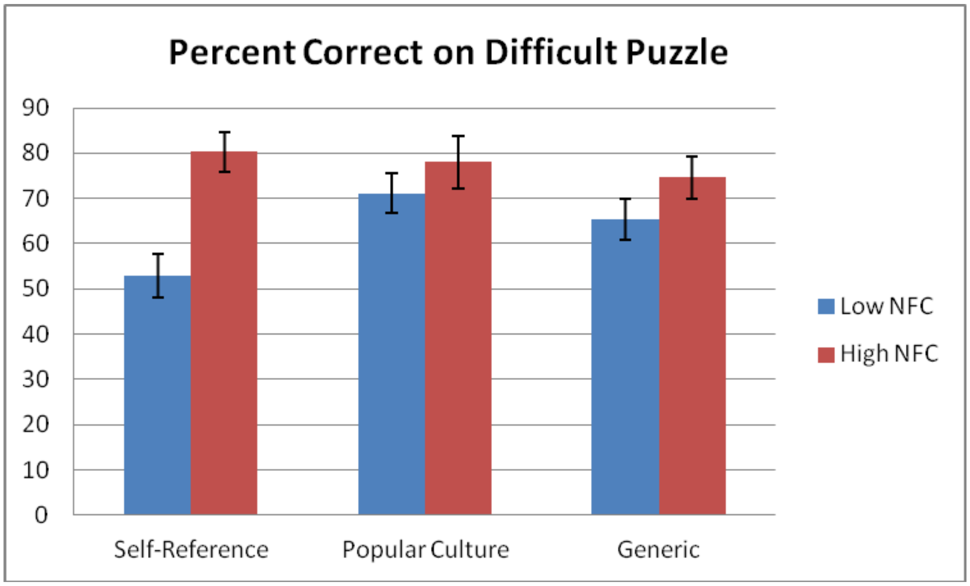

Figure 3. Condition x NFC interaction for percent correct on the difficult puzzle.

4.5 Time in the Tutorial

The average completion time for the tutorial was 633.16 seconds (s) ($SD = 199.576$ s), or 10.553 min ($SD = 3.326$ min). There were no main effects for time in the tutorial. There was a significant interaction for time in the tutorial between Condition and NFC, $F(2, 122) = 4.736$, $p = 0.010$, $\eta p^2 = 0.072$. To examine this interaction, a series of independent samples t-tests were run for those in each of the conditions.

For the Self-Reference condition, those with a high NFC spent significantly less time in the tutorial ($M = 588.15$ s, $SD = 160.378$ s) than those with a low NFC ($M = 751.11$ s, $SD = 257.599$ s), $t(43) = 2.612$, $p = 0.012$. For the popular culture condition, there were no significant differences between the amount of time those with high NFC ($M = 659.19$ s, $SD = 173.405$ s) and low NFC ($M = 569.08$ s, $SD = 151.171$ s) spent in the tutorial, $t(43) = 1.863$, $p = 0.069$. For the generic condition, there were no significant differences between the amount of time those with high NFC (*M* = 657.68, *SD* = 223.344) and low NFC (*M* = 605.00, *SD* = 198.326) spent in the tutorial, $t(42) = 0.827$, $p = 0.413$. See table 3 for the means and standard deviations for this interaction.

Table 3. Time spent in the tutorial for the condition x NFC interaction.

	Low NFC	**High NFC**
Condition	***M (SD)***	***M (SD)***
Self-Reference	751.11 s (257.599 s)	588.15 s (160.378 s)
Popular Culture	569.08 s (151.171 s)	659.19 s (173.405 s)
Generic	605.00 s (198.326 s)	657.68 s (223.244 s)

There was also a significant interaction for time in the tutorial between NFC and skill level, $F(1, 122) = 5.374$, $p = 0.022$, $\eta p^2 = 0.042$. Despite the interaction being significant, post-hoc independent samples t-tests revealed no significant differences for those who were low-skill level between the low NFC (*M* = 585.41 s, *SD* = 216.823 s) and high NFC (*M* = 686.70 s, *SD* = 159.931 s), $t(52) = 1.816$, $p = 0.075$. Further, there were no significant differences for those with high-skill level between the low NFC (*M* = 688.23 s, *SD* = 200.284 s), and high NFC (*M* = 609.59 s, *SD* = 193.681 s), $t(78) = 1.746$, $p = 0.085$.

4.6 Self-Report Ratings of Ease, Enjoyment, and Learning

Participants rated their agreement that they thought the tutorial was easy, enjoyed the tutorial, and that they learned a lot from the tutorial on a likert scale of 1 (strongly disagree) to 7 (strongly agree). See table 4 for the main effect tests for the self-report ratings. There were no significant main effects for ratings of enjoyment.

Table 4. Main effect *F*-Test for each rating.

Rating	Test	*F* Test	ηp^2	*p*-value
Ease	Condition	$F(2, 122) = 1.487$	0.024	0.230
	NFC	$F(1, 122) = 10.539$	0.080	0.002*
	Skill Level	$F(1, 122) = 3.297$	0.026	0.072
Enjoyment	Condition	$F(2, 122) = 0.192$	0.003	0.825
	NFC	$F(1, 122) = 2.349$	0.019	0.128
	Skill Level	$F(1,22) = 1.198$	0.010	0.276
Learning	Condition	$F(2, 122) = 0.008$	<0.001	0.992
	NFC	$F(1, 122) = 1.356$	0.011	0.246
	Skill Level	$F(1, 122) = 3.970$	0.032	0.049*

*Indicates a significant difference.

Ease. There was a significant main effect for NFC, so that those with high NFC ($M = 6.28$, $SD = 0.922$) rated the tutorial as easier than those with low NFC ($M = 5.63$, $SD = 1.167$), $F(1, 122) = 10.539$, $p = 0.002$, $\eta p^2 = 0.080$. Further, there was a significant interaction for condition and skill level, $F(1, 122) = 3.246$, $p = 0.042$, $\eta p^2 = 0.051$. A series of independent samples t-tests were run for each condition to examine this interaction. For the self-reference condition, those who were in the high-skill level group ($M = 6.29$, $SD = 1.084$) rated the tutorial as significantly easier than those in the low-skill level group ($M = 5.18$, $SD = 1.185$), $t(43) = 3.214$, $p = 0.002$. For the popular culture condition, there were no significant differences for the low-skill level ($M = 5.83$, $SD = 0.857$) or high-skill level ($M = 6.22$, $SD = 0.847$) groups, $t(43) = 1.501$, $p = 0.141$. For the generic condition, there were no significant differences for the low-skill level ($M = 5.95$, $SD = 1.026$) and high-skill level ($M = 5.96$, $SD = 1.274$) groups, $t(42) = 0.035$, $p = 0.972$.

Learning. There was a main effect of skill level, so that the high-skill level group ($M = 5.37$, $SD = 1.184$) indicated that they learned significantly more than the low-skill level group ($M = 4.89$, $SD = 1.254$), $F(1, 122) = 3.970$, $p = 0.049$, $\eta p^2 = 0.032$. In addition, there was a significant interaction between skill level and NFC, $F(1, 122) = 4.668$, $p = 0.033$, $\eta p^2 = 0.037$. To investigate this interaction, separate independent sample t-tests were run for each skill level. For those who were low-skill level, those with high NFC ($M = 5.35$, $SD = 1.268$) rated that they learned significantly more than those who were low NFC ($M = 4.62$, $SD = 1.181$), $t(52) = 2.142$, $p = 0.037$. For those who were high-skill level, those with high NFC ($M = 5.29$, $SD = 1.275$) were not significantly different on their ratings of learning than those who were low NFC ($M = 5.52$, $SD = 1.029$), $t(78) = 0.846$, $p = 0.400$.

5. Discussion

As expected, based on previous literature (Anand and Ross, 1987; Moreno and Mayer, 2000; Walkington and Maull, 2011), the impact of the SRE was evident in the difficult puzzle, which assessed transfer performance. Content questions, applied clue questions, and the easy puzzle did not exhibit differences based on the condition. In the current study, NFC was the most important predictor of the SRE's impact on the learning of the material. Consistent with the Cognitive Theory of Multimedia Learning (Mayer, 2005), the SRE did not benefit all participants in the same way. Self-reference material reduced cognitive load for both those who had a higher initial skill level (less effort needed to be devoted to learning the skill) and those who were high NFC (less effort needed to be devoted to relating the information to the self). As these two groups required less cognitive resources to learn the skill, they were able to learn it more deeply, which resulted in improved transfer performance.

5.1 The Need for Cognition interacts with the SRE

As with many other classic psychological effects, NFC appears to interact with the SRE. While self-reference traditionally aids instruction and transfer performance, in the current study, the opposite was found for those with low NFC. There was a significant difference in the self-reference condition such that those who were low NFC performed significantly worse than those who were high NFC. This result is consistent with the idea of incidental information in the Cognitive Theory of Multimedia Learning (Mayer and Moreno, 2003; Mayer, 2005), so that the inclusion of the individual's name actually distracted the low NFC individuals and required the use of additional cognitive resources. These results are also consistent with an additional cognitive effect, the Seductive Details Effect (SDE). The SDE is the tendency for extraneous details that are of interest, usually emotionally, to distract from learning and attention in text rather than help it (Harp and Mayer, 1997).

Individuals who are low NFC may be more easily distracted by the extraneous detail of their name being present and spend more time focused on it, rather than on processing the information and skills to be learned in the tutorial. One reason for this is that high NFC individuals are used to thinking deeply about information (Petty et al., 2009) and relating it to themselves, while low NFC are not. By priming those who are low NFC to picture and relate the information to themselves, it may be taking these individuals longer to process the information, and using additional cognitive resources, as they are sometimes referred to as "cognitive misers" (Cacioppo et al., 1996). This is also consistent with the time in tutorial interaction that was found between condition and NFC. For the self-reference condition, those who were low NFC spent significantly more time in the tutorial than those who were high NFC. This suggests that the low-NFC individuals were taking more time to read and process the information and potentially making more mistakes than those who were high NFC.

In addition, within those with low NFC, those in the popular culture condition scored significantly higher on the difficult puzzle than in the self-reference condition. It is possible that these low NFC individuals were distracted by thinking of themselves in the situation, whereas, including familiar characters provided a framework without the distraction, which led to improved transfer performance. This suggests that the activation of and linking information to an inappropriate idea is not the reason for the self-reference manipulation hurting their performance.

While the differences were not significant, those who were high NFC exhibited a pattern of transfer performance to be expected from the self-reference literature. High NFC individuals performed best on the difficult puzzle when they were in the self-reference condition, followed by the popular culture condition, and finally the generic condition. This suggests that including their own name did have a positive impact on those who are high NFC. The current study shows that individual differences may impact the effectiveness of the SRE when it is applied to an educational situation.

5.2 Initial Skill Ability Influenced Performance

As expected, the ability that the individual came into the experiment with, as assessed by the pre-test, did positively impact their performance for the more applied assessments. Consistent with the Cognitive Theory of Multimedia Learning (Mayer and Moreno, 2003; Mayer, 2005), for the high-skill individuals, having previous experience and skill with solving clues may have reduced cognitive load, making it easier for these individuals to learn, develop, and apply the skill in the difficult puzzle.

There was a significant skill level and condition interaction for ease ratings of the tutorial. For the self-reference condition, those who were high-skill level reported that the tutorial was significantly easier than those who were low-skill level. It is possible that the combination of already having abilities in deductive reasoning, and seeing one's own name throughout the tutorial, led the individual to perceive it as being less difficult than those who started out as low-skill level.

Further, there was a significant skill level and NFC interaction for scores on the content questions, and in self-ratings of how much was learned in the tutorial. Those who were low skill and low NFC reported that they learned less than those who were low skill and high NFC. Interestingly, their performance on the multiple choice and true/false questions also reflected this; the same group of low-skill individuals with low NFC scored significantly lower on the content questions than the low-skill individuals who were high NFC. These results suggest that for those who were not initially proficient at the skill, NFC level was predictive of their learning the content and perception of their own learning.

5.3 Implications for Education

It has previously been demonstrated that self-reference can be of benefit to individuals when they are learning concepts within math and science (Anand and Ross, 1987; Moreno and Mayer, 2000). However, the current study suggests that the individual difference of NFC level can have an impact on the effectiveness of this strategy for instruction. Low-NFC individuals were hurt by self-referential information being included as incidental information within instruction—it increased their cognitive load during learning. However, popular culture names from the series *Harry Potter* resulted in better transfer performance for those who were low NFC. This suggests that linking information to familiar characters and stories when teaching concepts and providing examples in the classroom can have a positive effect on the learning of these individuals, potentially by providing interesting material, and reducing cognitive load. Further, as the use of computer-based learning systems and individualized online learning increases, it is important to account for individual differences in characteristics that can be adjusted for NFC. By assessing whether or not an individual is high or low NFC before beginning tutoring, the system can adjust specifically to include self-reference information with high-NFC individuals but not with low NFC individuals who would be negatively impacted by it. The current study continues to shed light into the differences between high- and low-NFC individuals and strategies that can assist in deep learning.

5.4 Future Directions

In future studies, it would be advantageous to examine the impact of the self-reference and NFC with samples of elementary, middle and high school students to see if similar effects are transferable to non-college age students. Deductive reasoning is a highly cognitive task, which those with high NFC may be more apt to enjoy; therefore, future studies should see if similar results are found in less cognitive task domains. A measure of workload, such as the NASA-TLX scale would be beneficial to include in future work to specifically examine the cognitive load that participants have during and after the tutorial. Further, having a measure of performance and errors during the tutorial would lend more important insight into differences between performances of high- and low-NFC individuals during learning.

6. Conclusions

Those with high NFC performed better than those with low NFC on all of the performance measures (content, applied clues, and both puzzles) and rated the tutorial as significantly easier than those with low NFC. This strongly suggests that NFC is an individual difference that can impact what an individual learns from an educational tutoring program. Interestingly, those who were low NFC only benefited from including familiar character names within the learning material but were hurt by self-reference material. This suggests that careful consideration should be given to the examples used within learning material, in the classroom, and in computer-based tutoring, because those who are low NFC may react differently to it than is traditionally found in the psychology literature. It is important for the mystery of the need for cognition to continue to be investigated in order to deduce how it impacts education and learning.

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List of Symbols, Abbreviations, and Acronyms

ARL	U.S. Army Research Laboratory
DOP	depth of processing
DV	dependent variable
GIFT	Generalized Intelligent Framework for Tutoring
M	Means
min	minute
NFC	Need for Cognition
s	second
SD	Standard Deviation
SDE	Seductive Details Effect
SRE	Self-Reference Effect
VBA	Visual Basic for Applications

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RDRL HRT M C METEVIER
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J GRYNOVICKI
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