Relational Reasoning and Self-Directed Learning:
An Analysis of Their Effects on How Adults Process Information Online

by

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Abstract

The purpose of this study is to understand the relationship between self-directed learning readiness (SDLR), relational reasoning (RR), and Civic Online Reasoning (COR) for mid-career U.S. Air Force officers, U.S. Space Force officers, and Department of the Air Force civilians. A hypothesized model was built based on existing literature and previous research. This study was constructed around the two-factor theory of critical thinking. Despite improved critical thinking being a stated goal of Air Force Professional Military Education (PME), limited research exists on this population. MANOVA was used to determine the influence of the participants' highest level of education and promotion category on SDLR and RR. Hierarchical linear regression was used to determine the relative strength of SDLR and RR in predicting COR ability. The online survey was hosted through Qualtrics and included three COR tasks, the Test of Relational Reasoning (Alexander et al., 2016), and the Self-Directed Learning Readiness Scale (Fisher et al., 2001).

The sample was drawn from three classes of an in-residence PME course and students enrolled in the asynchronous version of the same course. Qualtrics registered 251 responses out of a population of 5,013 students (5.0%). After data screening, the final sample for COR task analysis included 95 participants (95/251, 37.8%) who successfully completed all three tasks with sufficient effort. The final sample for analysis of the hypothesized model was 69 (69/251, 27.5.%).

The study results indicated that most participants struggled to analyze information online. Analysis of the participant responses revealed that some were swayed by superficial indicators of credibility, partisan beliefs, and a general mistrust in their ability to find credible information

online. Analysis of the hypothesized model did not find that SDLR was a statistically significant predictor of COR ability. RR was a small but statistically significant predictor of COR ability.

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But the wisdom that is from above is first pure, then peaceable, gentle, and easy to be intreated, full of mercy and good fruits, without partiality, and without hypocrisy. James 3:17

Disclaimer

The views expressed in this study are those of the author and do not reflect the official policy or position of the United States Air Force, the Department of Defense, or the United States government.

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Chapter 1: Introduction

Information has long been a source of power in society. Leaders and other societal influencers have tried to control access to information and shape the prevailing narrative for their purposes (Burkhardt, 2017). The current information environment is characterized by the breadth of information available to individuals from various sources, an increase in polarization, and a decline in trust in facts and reasoned analysis (Huguet et al., 2019; Kavanaugh & Rich, 2018, Pollard & Kavanaugh, 2019). The amount of information individuals have access to has grown exponentially, especially with the increased prevalence of social media platforms (Kavanaugh & Rich, 2018). Information is more widely available and spreads more easily.

Social media, in particular, makes finding and vetting credible information more challenging. Previous research has shown that more and more adults are using social media platforms to find news (Newman et al., 2021; Pollard & Kavanaugh, 2019). Pollard and Kavanaugh (2019) found that 28% of Americans use social media as one of their top two sources of news. Newman et al. (2021) found that 42% of Americans used social media as one of their sources of news. One of the challenges of the diffusion of information sources is that the line between opinion and fact has continued to blur. Even social media users who are not looking for news are likely to see commentary and posts about current events that are likely to shape their opinions about the world. The sources of commentary are often celebrities and influencers with a broader reach than experts on a particular topic.

An additional challenge of the current information environment is the proliferation of misinformation and disinformation. Misinformation and disinformation refer to "false or misleading" information (Kavanaugh & Rich, 2018, p. 8-9). The key distinction is that misinformation is unintentionally spread while disinformation is purposely disseminated to achieve a particular goal. Jonathan Swift (1908, p. 408) wrote about the power of falsehood:

> Falsehood flies, and truth come limping after it, so that when men come to be undeceived, it is too late; the jest is over, and the tale hath had its effect: like a man, who hath thought of a good repartee when the discourse is changed, or the company parted; or like a physician, who hath found out an infallible medicine, after the patient is dead.

Modern examples have borne out Swift's concerns.

On April 23, 2013, hackers from the Syrian Electronic Army, a pro-Assad organization, took over the Associated Press (AP) Twitter account and tweeted that an explosion at the White House had injured then-President Barack Obama (Fisher, 2013). The stock market lost $136 billion within minutes until the rumors were shown to be false (Fisher, 2013). In March of 2006, U. S. Special Forces and Iraqi Special Forces soldiers conducted an operation against a group of Jaish al-Mahdi fighters suspected of murdering civilians (Dauber, 2009). After the operation was complete, other Jaish al-Mahdi fighters rearranged the scene and disseminated pictures of a supposed war crime committed by U.S. and Iraqi troops. The U.S. forces had photo and video evidence backing up their version of events but presenting a corrective narrative took significantly longer to produce than the original disinformation.

Though there are systemic problems in the modern information environment, the previous examples highlight the problems for the individual. The AP hack had a significant real-world impact but was fairly easy to refute. It is unlikely that people continue to believe that Barack Obama had been injured in a bombing. The evidence to the contrary is overwhelming and easy to access. The latter example poses a different challenge. It would be almost impossible to get the correction in front of everyone exposed to the disinformation, especially considering the time gap. The correction also may not have been seen as credible, especially to individuals opposed to U.S. intervention in Iraq. Research has also shown that even when false

claims are refuted, they tend to continue to influence people's judgments (e.g., de keersmaecker & Roets, 2017; Lewandowsky et al., 2017; Rich & Zaragoza, 2016; Sangalang et al., 2019). This phenomenon has been labeled the continued influence effect.

The challenge of dealing with information online has a multitude of consequences. From a societal standpoint, citizens must have access to and the opportunity to act based on truthful information (Burkhardt, 2017; Kahne & Bowyer, 2017; Knight Commission, 2009). Issues such as climate change, responding to a global pandemic, election security, and systematic injustice are complex enough on their own. People need to make decisions about which policies and politicians to support. Making this determination requires the ability to find and evaluate information from a variety of sources.

On a more personal level, adults need to parse through the cacophony of online information in their everyday lives. Researchers have looked at how well students from middle school to college can evaluate the credibility of information that they find online (Breakstone et al., 2019; Horn & Veermans, 2019; Marttunnen et al., 2021; Nygren & Guath, 2019). Issues like vaccine hesitancy have societal and very personal implications, so people must be making decisions with the best possible information. There is some evidence that access to the internet and its associated misinformation/disinformation leads to higher vaccine skepticism (Broniatowski et al., 2018; Lunz Tujillo & Motta, 2021). That is likely because of the prevalence of misinformation and disinformation. People also need to make decisions about careers, switching careers, pursuing education, and engaging in hobbies (Morris, 2019; Stebbins, 2017). These pursuits are more complicated without the ability to find trustworthy information.

The Hypothesized Model

Critical thinking is an oft-stated goal of education and is a potential individual mechanism for helping adults succeed in the current information environment. There is no consensus definition of critical thinking. Facione (1990) wrote that critical thinking is, in part, "purposeful, self-regulatory judgement." Facione (1990) also argued that critical thinking involves skills and affective dispositions. Alexander (2014) contends that critical-analytic thinkers are individuals who are "perceptive and attentive to the world around them and manifest the ability to think deeply and flexibly about important issues." These definitions generally agree that critical thinking involves higher-order cognitive processes requiring skills and dispositions. The two-factor theory of critical thinking provides a more distinct framework around the abovementioned definitions. The two-factor theory proposes that critical thinking skills are affected by cognitive abilities and personality dispositions (Clifford et al., 2004). In this model, relational reasoning (RR) and self-directed learning (SDL) represent the abilities and dispositions that would allow a person to engage in critical thinking, specifically in the context of social and political information found online.

Civic online reasoning (COR) is a concept that was developed by researchers from the Stanford History Education Group. It is defined as "…the ability to effectively search for, evaluate, and verify social and political information online." (McGrew et al., 2018, p. 165). Previous research has shown that both high school and college students struggle with evaluating the credibility of online sources both in the U.S. and abroad (Horn & Veermans, 2019; McGrew et al., 2018; McGrew et al., 2019; Nygren & Guath, 2019). In this model, COR is a specific concept where critical thinking skills are required. To successfully reason about civic issues online, a person must be able to think purposefully, deeply, and flexibly about the information they encounter online.

SDL can include a description of the learning environment (van Merriënboer & Sluijsman, 2009), process components (Brockett & Hiemstra, 1991), and personal attributes (Brockett & Hiemstra, 1991; Candy, 1991; Garrison, 1997). Previous researchers have suggested that the personal attributes of a self-directed learner are self-management (Candy, 1991; Garrison, 1997), self-monitoring (Garrison, 1997), and personal autonomy (Candy, 1991). Aspects of SDL, such as self-control (Duckworth et al., 2019) and self-management (Claro & Loeb, 2019), have been associated with academic achievement. SDL has also been conceptualized as an adaptive skill that can help people navigate a complex and changing world (Bliss, 2019; Morris, 2019). Learners who can plan and evaluate their learning while exhibiting self-control may better navigate the complexities of online information.

Relational reasoning (RR) is a measure of fluid intelligence and more complex reasoning abilities (Krawczyk et al., 2010). Alexander and the Disciplined Reading and Learning Research Laboratory (DRLRL) define RR as "recognizing or deriving meaningful relations or patterns between and among pieces of information that would otherwise appear unrelated" (2012). RR consists of four subcomponents: analogy, anomaly, antinomy, and antithesis. RR has been researched in relation to problem-solving (Dumas et al., 2016, Jablansky, 2020), critical thinking and individual interest in maternity nursing (Fountain, 2016), and expertise in medical education (Dumas et al., 2014). Previous research has identified the importance of cognitive abilities in making social judgments (Murphy & Hall 2010) and correcting previous judgments based on false information (De keersmaecker & Roets, 2017). People who are higher in RR may be better able to parse data and weed out low-quality sources and arguments.

Self-directed learning represents cognitive strategies (self-control and self-management) and dispositions (desire for learning) that may lead a person to look beyond surface-level

arguments and weak evidence online. Relational reasoning may provide the cognitive skills necessary to successfully utilize the strategies and dispositions of SDL in a complex information stream, as represented by COR.

Problem Statement

The challenge of navigating information online in a saturated media environment filled with falsehoods has been well-documented (e.g., Breakstone et al., 2019; Horn & Veermans, 2019; Marttunnen et al., 2021; Nygren & Guath, 2019). Researchers have found that people from all sections of society struggle to evaluate the information they encounter online. This struggle has both societal and personal implications. These struggles are despite a prolonged emphasis on critical thinking at all levels of education.

USAF and USSF officers and DAF civilians represent a distinct segment of the U.S. population. Each officer has at least a bachelor's degree. Most participate in a professional military education system that explicitly names critical thinking as a desired learning outcome (Chairman of the Joint Chiefs of Staff, 2020). Stone (2017) conducted one of the few empirical studies on this population and found that most of the officers in his population struggled with critical thinking. More research is needed to clarify the extent of this population's reasoning skills and identify potential mechanisms for improvement.

This study will investigate the extent of COR skills, SDLR, and RR ability in the population of mid-career USAF and USSF officers and Department of the Air Force civilains. The study will also test a model for online reasoning skills based on the two-factor theory of CT. The findings will fill gaps in the literature by studying these constructs in a unique population while also exploring their relationships.

Purpose of the Study

The purpose of this non-experimental, quantitative, correlational study is to explore the relative influence of relational reasoning ability, and self-directed learning readiness on online reasoning ability in mid-career Total Force USAF/USSF members enrolled in the in-residence and asynchronous offerings of a professional military education course. The hypothesized model was built based on prior research and the existing literature. Online reasoning ability is the dependent variable, while SDLR and RR were the independent variables. This study will address specific gaps in the literature such as a lack of research on this population and investigate relational reasoning and self-directed learning in the context of critical thinking. The findings will provide additional nuance to the understanding of reasoning skills in this population while also providing an initial investigation of SDLR and RR. The overall model will provide an initial investigation of the relationship between these competencies. SDLR was measured with the previously validated SDLRS (Fisher et al., 2001). The Test of Relational Reasoning (TORR) (Alexander et al., 2016) was used to measure RR, while three previously studied tasks developed by the SHEG (McGrew et al., 2018) were used to assess COR ability.

Research Questions and Hypotheses

To address the gaps in the literature and the challenges outlined above, the research questions for this study are:

Research Question 1: Do the chosen COR tasks discriminate between different levels of reasoning ability in mid-career USAF and USSF officers and DAF civilians?

Previous researchers have used the COR tasks to measure the abilities of students in middle school through college. The tasks were designed to test the abilities of different age groups, but they have not previously been used with a population of mid-career professionals.

This study uses tasks that challenged university students but that have not been investigated with a population of working professionals.

Research hypothesis: Participants' scores on the chosen COR tasks show different levels of reasoning ability in mid-career USAF and USSF officers and DAF civilians.

Null hypothesis: The chosen COR tasks do not discriminate between different levels of reasoning ability in mid-career USAF and USSF officers and DAF civilians.

Research Question 2: Does the hypothesized model allow us to reliably predict performance on online reasoning tasks in mid-career USAF and USSF officers and DAF civilians?

The hypothesized model is based on the two-factor theory of critical thinking. COR is operationalized as a real-world assessment of critical thinking skills in action. The model combines SDLR and RR as dispositions and skills respectively that would enable a person to engage with online information successfully. This investigation looked at domain-general reasoning abilities, and SDLR and RR are also conceived of as domain-general. The model also assumes that the highest level of education and promotion category would influence RR and SDLR without exerting a direct effect on COR.

Research hypothesis: Participants with higher levels of SDLR and RR will have higher COR ability.

Null hypothesis: The hypothesized model does not reliably predict performance on online reasoning tasks in mid-career USAF and USSF officers and DAF civilians.

Research Question 3: Which of the predictor variables are most influential in predicting performance on online reasoning tasks?

Research hypothesis: SDLR and RR will be statistically significant predictors of COR ability. SDLR will be the strongest predictor in the hypothesized model.

Null hypothesis: Neither of the predictor variables reliably predict performance on online reasoning tasks in mid-career USAF and USSF officers and DAF civilians.

Research Question 4: Do promotion category and level of education predict RR ability among mid-career USAF and USSF officers and DAF civilians?

Promotion categories represent groups of jobs that have similar development paths and career field expectations. Relational Reasoning is an ability that can be developed, and different forms of relational reasoning can be reinforced to varying degrees based on the situation (e.g., Dumas et al., 2014). The different career field paths could foster relational reasoning to varying degrees. Additionally, some career fields could attract officers with different base levels of RR ability.

Different levels of educational attainment among the participants may account for some of the individual differences in relational reasoning ability. As the USAF and USSF continue to try to improve critical thinking skills across the officer population, the relative impact of factors like level of education may provide useful insight into future interventions.

Research hypothesis: Participants with higher levels of education will have higher levels of RR. There will be statistically significant differences in RR between some promotion categories.

Null hypothesis: Promotion category and level of education are not significant predictors of relational reasoning ability of mid-career USAF and USSF officers and DAF civilians.

Research Question 5: Do promotion category and level of education predict SDLR for mid-career USAF and USSF officers and DAF civilians?

Similar to relational reasoning, SDLR could be fostered differentially among career fields. Different jobs require different levels of independence and responsibility at different points in an officer's career, which may lead to varying manifestations of SDLR. As with RR,

various career fields may appeal to officers with different baseline inclinations towards SDLR. Understanding how SDLR varies based on the participants' promotion category could lead to a more in-depth investigation of what factors influence SDLR within different career fields.

Research hypothesis: Participants with higher levels of education will have higher levels of SDLR. There will be statistically significant differences in SDLR between some promotion categories.

Null hypothesis: Promotion category and level of education are not significant predictors of SDLR in mid-career USAF and USSF officers and DAF civilians.

Significance of Study

The challenges of the information environment at large are particularly acute in the military and international security context. From the highest levels of government, there is an awareness of the challenge of misinformation/disinformation and the charge for the military to be prepared. In the most recent National Security Guidance, President Biden calls disinformation a threat to democracy and argues that hostile actors are actively working to influence the information environment (White House, 2021). In the most recent National Defense Strategy, former Secretary of Defense Mattis warns of "information subversion" and calls on the military to "out-think" their adversaries (Mattis, 2018). This top-level guidance translates to a vision for Professional Military Education (PME) to develop "strategically minded joint warfighters who think critically and can creatively apply military power to inform national strategy, conduct globally integrated operations, and fight under conditions of disruptive change" (Chairman of the Joint Chiefs of Staff, 2020).

The challenge with this guidance is that CT is often not well defined, and it is hard to measure. This study seeks to measure COR as an increasingly important aspect of critical

thinking. The COR tasks are an authentic measure of online reasoning, and this study will provide baseline data for this population. Additionally, the proposed model will provide a structure for skills and dispositions related to critical thinking. The results of this analysis may suggest possible interventions to improve CT skills, and it will set the stage for future research into this vital topic.

Assumptions

1. The students in the in-residence and asynchronous courses are representative of mid-career officers and DAF civilians across the USAF and USSF.
2. The COR tasks are appropriate for this population.

Limitations

1. This is a non-experimental quantitative research study where the researcher could not manipulate the independent variables.
2. The survey had a low overall response rate. Every student from three iterations of the in-residence course and all students enrolled in the asynchronous course as of March 22, 2022, were invited to participate (5,013 total students). Of the 251 students who registered a response in Qualtrics, 182 (72.5%) were not retained in the final dataset. Students were advised that the survey would take approximately 60 minutes to complete, which likely limited the number of students willing to participate. This factor also probably influenced the type of student who attempted participation. Asynchronous students were contacted via email, and those emails may have been deleted or ignored.
3. The length of the survey may have caused participants to lose interest and try to click through parts of the survey as quickly as possible to receive compensation.

4. Critical thinking is expansive, and it is almost impossible to create a study to examine every aspect of what CT could be. This research attempted to find elements of CT that would be relevant to the specific issue of online information processing at the expense of facets of CT.

5. Participants may have answered the self-report questions in a way that portrayed them in a positive light. Additionally, participants may not always have an accurate view of themselves.

Definition of Terms

Active Duty: Enlisted or officer service members who are performing full-time duty (DOD Dictionary, November 2021, p. 7)

Air Force Reserve (AFR): The Air Force Reserve is one of the reserve components of the USAF. The AFR provides "trained units and qualified persons" (Purpose of reserve components, 2011) to support the regular components during times of conflict, emergency, or as required by the President.

Air National Guard (ANG): The ANG is one of the reserve components of the USAF. The ANG has a dual role of serving both a federal and state mission (Air National Guard, n.d.). In support of these roles, the ANG provides "trained units and qualified persons" (Purpose of the reserve components, 2011) to support the regular components during times of conflict, emergency, or as required by the President or governor.

Company grade officer (CGO): In the Air Force, CGOs are junior officers serving in the ranks of Second Lieutenant, First Lieutenant, or Captain.

Critical thinking: There is no consensus definition of critical thinking. For this study, critical thinking is "purposeful, self-regulatory judgement" (Facione, 1990) and includes both cognitive skills and the disposition to use those skills in all aspects of life.

Civic Online Reasoning: Civic Online Reasoning is the "ability to effectively search for, evaluate, and verify social and political information online" (McGrew et al., 2018).

Disinformation: Disinformation is "false or misleading information spread intentionally…" (Kavanagh & Rich, 2018). Disinformation is usually spread to achieve a particular goal, such as motivating the public or creating confusion (Kavanagh & Rich, 2018, p. 8).

Misinformation: Misinformation is "false or misleading information that is spread unintentionally, by error or mistake…" (Kavanagh & Rich, 2018, p. 10).

Officer: Officers in the Air Force have at least a bachelor's degree and are appointed by the President (Kapp, 2021; Appointments in regular components, 1982). Officers make up 18.5% of the Air Force (Office of the Under Secretary of Defense, Personnel and Readiness., 2019, p. 3) and outrank all enlisted members.

Professional military education (PME): PME includes a range of courses and programs designed to "equip attendees with knowledge, skills, and/or experience to succeed in the performance of DoD missions..." (Chairman of the Joint Chiefs of Staff).

Relational reasoning: RR is "the ability to recognize or derive meaningful relations between and among pieces of information that would otherwise appear unrelated" (Alexander and the DRLRL, 2012). This study assumes RR has four subcomponents: analogy, anomaly, antinomy, and antithesis (Alexander and the DRLRL, 2012).

Analogy: Analogical reasoning is the ability to recognize the similarities between ostensibly different ideas (Alexander & DRLRL, 2012).

Anomaly: Anomalous reasoning is the ability to differentiate data that does not fit within the identified pattern or rule set (Alexander & DRLRL, 2012).

Antinomy: Antinomies are reasonable ideas or data that are categorically incompatible (Alexander & DRLRL, 2012).

Antithesis: antithetical reasoning relates to directly contrasting information (Alexander & DRLRL, 2012).

Self-directed learning: SDL is a "process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes," (Knowles, 1975, p. 18).

Total Force: The Total Force includes the AD, AFR, ANG, Department of the Air Force civilians, and contractors. The Civil Air Patrol is also included in the Total Force if they are operating as part of the Air Force Auxiliary (AF Glossary, n.d.).

Organization of the Study

Chapter 1 introduced the topic and context of the study. The model was also introduced along with the problem statement, the purpose of the study, the research questions and hypotheses, the significance, and finally, definitions of important terms. Chapter 2 includes a review of the literature and an explanation of the study's theoretical foundation. The two-factor theory of critical thinking is presented as a guiding framework that links self-directed learning readiness and relational reasoning to civic online reasoning. Chapter 3 describes the methods used in this study and a description of the population, sample, instruments, and data collection and analysis procedures. Chapter 4 includes an examination of the study's results, and finally, Chapter 5 summarizes the study, presents the implications, and provides recommendations for future research and practice.

Chapter 2: Literature Review

Overview

This literature review will examine the current information environment and the influence of misinformation and disinformation. Then research dealing with the conceptual model presented in Chapter 1 will be discussed. The two-factor theory of critical thinking will be explored, followed by research about civic online reasoning. Then self-directed learning and self-direct learning readiness will be considered. Finally, research about relational reasoning will be reviewed. For each component of the model, consideration will be given to the conceptualization of the concept, measurement, and findings from empirical research.

Problem Statement

The challenge of navigating information online in a saturated media environment filled with falsehoods has been well-documented (e.g., Breakstone et al., 2019; Horn & Veermans, 2019; Marttunnen et al., 2021; Nygren & Guath, 2019). Researchers have found that people from all sections of society struggle to evaluate the information they encounter online. This struggle has both societal and personal implications. These struggles are despite a prolonged emphasis on critical thinking at all levels of education.

USAF and USSF officers and DAF civilians represent a distinct segment of the U.S. population. Each officer has at least a bachelor's degree, and most participate in a professional military education system that explicitly names critical thinking as a desired learning outcome (Chairman of the Joint Chiefs of Staff, 2020). Stone (2017) conducted one of the few empirical studies on this population and found that most of the officers in his population struggled with critical thinking. More research is needed to clarify the extent of this population's reasoning skills and identify potential mechanisms for improvement.

This study will investigate the extent of COR skills, SDLR, and RR ability in the population of mid-career USAF and USSF officers and DAF civilians. The study will also test a model for online reasoning skills based on the two-factor theory of CT. The findings will fill gaps in the literature by studying these constructs in a unique population while also exploring their relationships.

Current Information Environment

Information has always been a means of control. Leaders would often have greater access to and the ability to disseminate the information that supported their institutions. Concurrently false or misleading information could be just as valuable as the truth (Burkhardt, 2017). What changes over time is the ability of people to produce and consume information, some of which is inevitably false. The printing press and increased literacy eventually created a market for written information. Aretino wrote satirical pamphlets criticizing public figures (Burkhardt, 2017), while "Canards" were newspapers full of fake stories sold on the streets of Paris (Baptista & Gradim, 2020). The yellow journalism of the late 1800s contained exaggerated news intended to influence opinions and blurred the line between facts and opinions (Kavanagh & Rich, 2018). The 1960s and 1970s saw a decline in trust in news organizations, coinciding with a steep decline in overall trust in the government (Kavanagh & Rich, 2018). These trends, which have been around for as long as people have been communicating, have led to a world where fake news is a common phrase and trust in media is low. The RAND Corporation has labeled this phenomenon Truth Decay. Truth Decay is defined as "the diminishing role that facts, data, and analysis play in our political and civil discourse" (Huguet et al., 2019, p. 1).

Kavanagh and Rich (2018) laid out four trends that are not new but that have grown in intensity in the current information ecosystem. The first trend is growing disagreement about

data and reasoned analysis of facts and information. The second trend is that, much like the yellow journalism era, fact and opinion are integrated in ways that make them hard to distinguish. Third, personal experience and opinions are becoming more important and powerful in discourse about presumably factual issues. The fourth trend is that people are losing their trust in formerly reputable distributors of information. Barzilla and Chinn (2020) similarly described the current information environment but added that news consumption is becoming increasingly fragmented and that misinformation and disinformation are increasingly prevalent.

The internet and social media exacerbate the problem of truth decay by furthering the Truth Decay trends. The Online Accessibility hypothesis argues that exposure to misinformation, disinformation, and conspiracy theories makes people more skeptical about all information. Lunz Trujillo and Motta (2021) examined data for 149,014 people from 144 countries to assess their level of vaccine skepticism. Vaccine skepticism has been around for as long as there have been vaccines, but it has become more prominent. Within the last quarter century, there has been a persistent belief that the MMR vaccine causes autism (Poland & Spier, 2010). Much of this misinformation originated in a discredited paper that continued to influence beliefs even after it had been retracted (Larson et al., 2011; Poland & Spier, 2010). Lunz Trujillo and Motta (2021) found that accounting for other factors vaccine skepticism was positively correlated with nationwide internet access across their sample. It seems that as people are exposed to an information environment cluttered with misinformation, their trust in all information decreases.

These trends become increasingly important as more people get their news from social media. Pollard and Kavanagh's (2019, p. 27) survey showed that 38% of Americans listed online news sources among their top two most-used news sources, while 28% listed social media. The

2021 Digital News Report (Newman et al.) found that 66% of people got their news from all online sources, while 42% specifically mentioned social media as a news source. One of the complications of social media is that users are exposed to misinformation and disinformation even if they are not using it for news. In line with the second and third trends from Rich and Kavanagh (2018), personal experiences are amplified, and there is no clear differentiation between fact and opinion. Influencers, celebrities, and everyday people fill news feeds with a mix of personal stories, commentary, and news. This mix makes it more difficult for the average person to sift through the information stream to find credible information. There is also evidence that misinformation is more insidious when it is not explicit. When opinion is mixed with fact and not easily distinguished, people may be less willing to question the narrative they are building in their minds.

Researchers have shown that implied misinformation is more challenging to correct than explicitly stated misinformation. Rich and Zaragoza (2016) provided participants with a story about a robbery. In one condition, participants were explicitly told the victim's son was a suspect, which was later corrected. In another treatment condition, researchers implied that the son was the thief because he was the last one with access to the stolen property. The participants were later told the son had an alibi. Participants in the implied condition were more prone to continue believing the son was guilty, despite direct evidence to the contrary. This phenomenon is referred to as the Continued Influence Effect. This experiment is similar to what can happen online. People on social media are likely to hear stories and anecdotes that lead them to conclusions based on a mix of facts and opinions. Those created narratives tend to persist and are hard to change, even in the face of new evidence.

This information environment also makes it easier for humans' cognitive biases to play out. People can readily find information that confirms their preexisting beliefs. As Barizilla and Chinn (2020) pointed out, the news environment is increasingly fragmented. This fragmentation allows people to consistently hear one side of an issue without opposing voices. The Digital News Report (Newman et al., 2021) found that while only 29% of people trusted the news, 44% trusted the news that they use. These "echo chambers" that are created are likely to reinforce the negative aspects of the current information environment and potentially degrade overall civic discourse (Barzilla & Chinn, 2020). The influence of political partisanship and polarization on reasoning has also been investigated by others, including Kahne and Bowyer (2017), Lazer et al. (2017), and Spezano and Winiecki (2020).

The internet is ubiquitous for many adults, and Truth Decay can have real consequences in their lives. Democratic society is built on the idea that citizens collectively can make decisions that lead to widely beneficial policies (Kahne & Bowyer, 2017). That may not always be realistic, but Truth Decay makes that outcome less likely as the basic facts about issues such as vaccines (e.g., Lunz Trujillo &Motta, 2021) and climate change are debated (e.g., Damico et al., 2018). On a personal level, adults also need the ability to find and use reliable information on the internet in their everyday lives. As the world changes, people must continually adapt, which requires learning new information and skills (Morris, 2019). The internet provides an essential avenue for continuing to engage with new ideas outside formal education institutions.

Misinformation, disinformation, and the complex information environment are both individual and systematic problems. The internet and social media vastly increased the volume of information people are exposed to in their everyday lives. New information is also constantly available. This information flow is influenced by algorithms designed to captivate attention

(Baptista & Gradim, 2020; Kavanagh & Rich, 2018; Spezzano & Winiecki, 2020). There are also malicious actors who are purposely attempting to complicate the information system. Foreign governments can seek to influence or confuse by using inauthentic social media accounts (Broniatowski et al., 2018; Kavanagh & Rich, 2018). Limiting the exposure to misinformation and disinformation at the societal level requires structural changes, but there also have to be solutions at the individual level. The Continued Influence Effect highlights the need to build the capacity to counter misinformation and disinformation in everyone. Critical thinking has been proposed as a mechanism for battling misinformation at the individual point of exposure (Axelson et al., 2021; Barzilai & Chinn, 2020; Horn & Veermans, 2019; Zucker, 2019).

Critical Thinking

Critical thinking has been conceptualized as more than just a cognitive skill. Facione (1990) wrote that critical thinking is, in part, "purposeful, self-regulatory judgment." Facione (1990) also argued that critical thinking involves skills and affective dispositions. Alexander (2014) contends that critical-analytic thinking entails individuals who are "perceptive and attentive to the world around them and manifest the ability to think deeply and flexibly about important issues." These definitions generally agree that critical thinking involves higher-order cognitive processes requiring skills and dispositions. Facione's (1990) definition specifically mentions self-regulation, while Alexander's (2014) highlights flexibility.

The two-factor theory of critical thinking provides a more distinct framework around the definitions provided above. The two-factor theory proposes that critical thinking skills are affected by cognitive abilities and personality dispositions (Clifford et al., 2004). Ennis was one of the first scholars to advocate for a two-factor theory of critical thinking explicitly. He wrote that critical thinking needed to be considered both dispositions and abilities and that critical

thinking was a practical activity (Ennis, 1985). Ennis asserts that critical thinking is a purposeful activity and that individuals must choose whether to engage in it. Additionally, people may want to pursue critical thinking while being limited by their cognitive abilities. Conversely, individuals may have the requisite cognitive abilities yet still choose not to engage in purposeful thinking.

The two-factor theory has been expanded by scholars who worked to define both the skills and dispositions of critical thinking. Facione (1990) authored a formative report on critical thinking that outlined six cognitive skills agreed upon by 46 experts in an American Psychological Association-sponsored Delphi study. Critical thinking entails interpretation, analysis, evaluation, inference, explanation, and self-regulation (Facione, 1990). The Delphi study report also laid out affective dispositions of critical thinking: inquisitiveness, the concern to be well-informed, alertness to the need to use critical thinking, trust in reasoned thought, self-confidence that one can reason well, open-mindedness, flexibility, empathy towards others' opinions, fairmindedness, honesty about one's biases and faulty heuristics, the ability to suspend judgment, and a willingness to change one's mind as necessary (Facione, 1990). Elder and Paul (1998) add intellectual humility, intellectual perseverance, intellectual courage, and intellectual independence as important facets of intellectual character.

CT in the Air Force

Developing critical thinking skills in the military is a focus of senior military leaders. In 2020, the Joint Chiefs of Staff wrote that the dynamic and complex international environment required leaders who could think critically and creatively in a constantly changing world (Chairman of the Joint Chiefs of Staff, 2020). This emphasis on critical thinking has been reinforced in the most recent Officer Professional Military Education Policy (OPMEP). The

OPMEP directed that, in addition to other focus areas, military schools should be developing officers with demonstrable critical thinking skills (Chairman of the Joint Chiefs of Staff, 2020). Despite this emphasis, there has been little empirical research on the state of CT within the military.

Stone (2017) conducted one of the few studies on this population. In his study, students from three schools for mid-late career officers took the Watson-Glaser Critical Thinking Appraisal. Stone compared the results for students from each school. Two of the schools (Air Command and Staff College and Air War College) are attended by the top 20% of the Air Force at their respective ranks. The third school (the School for Advanced Air and Space Studies) is populated by students selectively chosen from students at Air Command and Staff College or equivalent schools from other branches of service. Stone found no statistically significant differences in scores for Air Command and Staff College students and the higher-ranking students at Air War College. The School for Advanced Air and Space Studies students scored higher than those at Air Command and Staff College.

Stone's (2017) study represents one attempt to measure the critical thinking skills of military officers. More research is needed to determine the full extent of critical thinking stills within the Air Force and to provide additional insight into mechanisms to improve those skills. Stone did not include officers from the population of this study and only used one measure of CT ability.

Challenges in Measurement

The limitations of the Stone study are common in research involving CT. Measuring CT is a complicated endeavor. Standardized tests are popular, but they are not authentic tasks. Students who perform well on a standardized assessment may not perform as well on an

academic task requiring them to demonstrate CT skills independently (Rear, 2019). Additionally, standardized assessments generally evaluate different components of CT in isolation. There is an ongoing debate about whether CT is domain-specific or domain-general. Some researchers believe that there are both specific and general aspects to CT (Facione, 1990, Elder & Paul, 1998).

An exact definition of CT remains vague, and measurement depends mainly on context (Alexander, 2014). The two-factor theory of CT provides a theoretical foundation for the relevant subcomponents. Civic Online Reasoning could be an appropriate real-world outcome of CT ability and dispositions within a specific context that is worth investigating. Additionally, SDLR may address motivational and dispositional components, while RR may address cognitive abilities

Civic Online Reasoning

Civic online reasoning (COR) is the "ability to effectively search for, evaluate, and verify social and political information online" (McGrew et al., 2018). This definition of COR is directly relevant to the issues of Truth Decay brought up by Kavanagh and Rich. Though the definition of COR specifically highlights abilities, dispositional components are also necessary to "effectively" deal with information in the online environment. COR is built off the work of scholars like Kahne & Bowyer, who address the challenge of motivated reasoning. People are often predisposed to filter their thinking through their prior beliefs, which is at the heart of motivated reasoning (e.g., Kahne & Bowyer, 2017; Flynn et al., 2017; Tabor & Lodge, 2016). This predisposition is influenced by the situation and environment, making investigating more challenging. Success in COR could predict people who are more likely to overcome these predispositions and use their reasoning skills to navigate the online information environment.

These abilities and dispositions encompass many of the same skills highlighted by Facione (1990) and require the deep and flexible thinking described by Alexander (2014).

Related subjects

COR is a subset of Media Literacy, defined as the "abilities to access, analyze, evaluate, and communicate media messages in a variety of forms" (Huguet et al., 2019, p. 3). Media literacy explicitly includes the ability to craft media messages forthrightly, which goes beyond the scope of COR. Information literacy is another concept that is related to COR. Information literacy deals with the broader information ecosystem than just the internet (ACRL, 2016). Similar to media literacy, the scope of information literacy also extends beyond just finding and evaluating information. Core aspects of information literacy include understanding how information is produced and disseminated and responsibly participating in the information ecosystem. These are admirable goals of education but fall outside the scope of COR.

Relationship to CT

Civic online reasoning is a concept that can be used to evaluate critical thinking in an environment characterized by Truth Decay. Facione (1990) highlights that critical thinkers must be alert to the fact that they need to engage in CT and be invested in wanting to be well-informed. As a person encounters misinformation online, the person with a high level of COR would be alert to the possibility of false information and would engage in evaluation and verification. The evaluation and verification steps would require other critical thinking skills such as fairmindedness and the ability to overcome biases and faulty heuristics. These concepts align with Alexander's (2014) definition as well. A person low in COR ability, as defined, would be less likely to think "deeply and flexibly" about the information they find online.

Measurement

Part of the challenge with investigating the problem of misinformation is the variety of constructs and formats that research can take. Information literacy, media literacy, digital literacy, and other constructs all deal with how individuals deal with the flood of information they encounter. COR provides a focused construct that deals specifically with social and political information with personal and societal implications. Additionally, because the skills and dispositions needed to succeed at COR align closely with the skills and dispositions of critical thinking, it provides a helpful outcome variable in a study of the two-factor theory of critical thinking.

Researchers have examined how people interact with information online in various ways. Spezzano and Winiecki (2020) provided participants with some details (title, associated images, source bias rating, and an excerpt based on their treatment condition) about a mix of real and fake news stories. Sindermann et al. (2021) used headlines and sub-headlines to test the participants' ability to spot fake news. Kahne and Bowyer (2017) used political cartoons and infographics with captions portraying various ideological stances to test how partisanship influenced the participants' judgment about the accuracy of the post. Marttunen et al. (2021) had Finnish upper secondary students review a YouTube video and a blog post. The participants were then asked to judge the post's credibility and evaluate the arguments posed. McGrew et al. (2018) designed tasks specifically to evaluate COR. The tasks varied in complexity and were modeled after information students are likely to find online, similar to the study by Marttunen et al. Participants were presented with something like a blog post or a tweet and were asked to analyze the information presented. Similar tasks were used with students in Sweden (Nygren & Guath, 2019) and Finland (Horn & Veermans, 2019)

The COR tasks created by McGrew et al. (2018) also have the advantage of being easily accessible and flexible in implementation. Several of the tasks have been used on students of various ages, allowing researchers to compare results easily. The tasks also measure what the participants would do when confronted with information of an unknown quality online. The COR tasks provide a more comprehensive instrument that can readily be used for research on a new population. This will make for easier comparisons with other populations.

Research on COR

Many researchers have found that people tend to fall victim to some form of motivated reasoning which impacts their ability to differentiate fact from fiction online (Kahne & Bowyer, 2017; Nisbet et al., 2015; Spezzano & Winiecki, 2020). In their initial study, McGrew et al. (2018) assessed the COR skills of 2,616 middle school, high school, and college students. On one task, students viewed a photo of supposedly mutated flowers from social media with a caption. They were asked to evaluate whether the image provided strong evidence about the environmental conditions near the Fukushima Daiichi Power Plant (McGrew et al., 2018, p. 177). The tasks used varied in difficulty, but the overall results showed that the majority of students at each level struggled to accurately assess the credibility of sources, appropriately consider the strengths and weaknesses of an argument, or successfully find other references to evaluate a claim (McGrew et al., 2018).

Horn and Veermans (2019) administered COR tasks to measure critical thinking to high school students in Finland. Students who had completed an International Baccalaureate Diploma Programme performed better than those entering the school, but many of the students still struggled to perform at the mastery level. The researchers attributed the increased success of the program's graduates to explicit critical thinking instruction in the curriculum (Horn & Veermans,

2019). Researchers in Sweden administered tasks similar to those created by McGrew et al. (2018) and reported similar results (Nygren & Guath, 2019). They also found that the students' self-reported online searching abilities did not correlate with improved task performance.

Self-Directed Learning

SDL has been an important area of study in adult education, beginning with the work of Cyril Houle, Allen Tough, and Malcolm Knowles in the 1960s (Merriam & Baumgartner, 2020). Knowles (1975, p. 18) defined SDL:

> In its broadest meaning, 'self-directed learning' describes a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes.

Knowles' definition of SDL was broad, but it touched on concepts that became more fully formed through later scholarship. The five steps imply several skills and dispositions required to engage in SDL. Taking the initiative is the disposition to engage in the process of learning. Addressing the idea of with or without others allows for a range of environments where SDL can take place, both inside and outside formal learning. Identifying and choosing resources requires the ability to evaluate the credibility and value of different learning materials and appropriately apply them to the task at hand. Learning strategies are likely honed through formal education and then may need to be translated to other contexts in non-formal and informal learning environments. Evaluating learning outcomes requires self-reflection and having specific learning goals in mind. Knowles's definition broadly sets the stage for further research on SDL's processes and individual components.

Stubblefield (1981) identified four phases people go through when undertaking an SDL learning project. In the initiating phase, learners determine their learning intentions. The planning phase deals with finding resources and activities that are most appropriate for achieving the learning goal. In the managing phase, learners examine their progress and synthesize their learning with their previous experiences. Finally, in the evaluating phase, learners must determine if they succeeded in their learning project. Examining each of the four phases provides a guide for learners similar to the steps laid out by Knowles.

Fundamentally, self-directedness in learning exists on a continuum (Candy, 1991; Knowles, 1979; 1990). The continuum exists between teacher-driven, highly structured learning opportunities towards an environment where students execute the previously outlined process of SDL. The learners would choose what they wanted to know and how to go about the learning process. The learning process could be scaffolded in a formal academic setting or undertaken individually in lifelong learning pursuits. Knowles was primarily interested in adult learning, and much of the research on SDL has been done in an adult learning context.

Cognitive components

The work by early SDL scholars like Knowles and Stubblefield was primarily descriptive, seeking to clarify processes that were seen in adult learners. Cavaliere completed a case study of the SDL undertaken by the Wright brothers in their pursuit of human flight. By studying the Wright brothers' process, Cavaliere (1992) identified five stages for an independent, self-directed learning project that took place away from a formal educational environment. The five stages included inquiring, modeling, experimenting and practicing, theorizing and perfection, and actualizing (Cavaliere, 1992). Cavaliere also incorporated four cognitive processes that were necessary throughout each stage of learning. As the Wright brothers built

their airplane, they were in a constant cognitive cycle of goal setting, focusing, persevering, and reformulating. The five stages and four cognitive processes provide a more complex conceptualization of SDL.

Contextual Considerations of SDL

Not all learning endeavors are the same. As people age, less of their learning takes place in formal learning environments. Informal and non-formal learning opportunities become more and more important later in life. Spear and Mocker (1984) outlined four patterns to describe the typical circumstances for adult learning projects, as shown in Figure 1.

Figure 1

Four Patterns of Learning Projects

	Learning circumstances
Type I	Single event, the need to learn is anticipated
Type II	Single event, the need to learn is not anticipated
Type III	Series of events, the learning is related
Type IV	Series of events, the learning is unrelated

Note. Spear & Mocker, 1984

The four patterns' significance is that they shed light on the range of learning situations that adults tend to encounter and the unique circumstances that can lead someone to engage in a learning project. Often, an adult will face a situation that motivates them to engage in a learning project.

Clardy (2000) identified four types of "vocationally-oriented" self-directed learning projects that add additional insight into why adults choose to engage in learning. Induced SDL projects are often driven by changes in the work environment that require someone to learn new skills or processes to continue in their position. Voluntary learning projects are driven solely by the initiative of the person. This could be a desire to learn skills for a different career or a more advanced position in the work setting. Synergistic learning projects happen when circumstances

and personal motivation line up to influence the scope of the learning. A new task at work combined with the desire to go above the minimum job requirements differentiates these learning projects from other types. The final type of SDL learning project is scanning. Scanning learning projects happen when a person continually engages in learning new developments about a particular field or area of knowledge. These projects are typically long-term and driven by a desire to stay informed without a specific learning outcome in mind.

There is considerable overlap in the categories defined by Spear and Mocker and Clardy. Adults often learn because they have to, and learning is often tied to employment considerations. The scope of learning can be as simple as learning a new task or preparing to enter a new career field. The avenues for engaging in learning are as varied as the types of learning projects. Adults also choose to learn outside of their vocation as well. Stebbins (2007) argues that SDL is also relevant to how adults engage in lifelong learning in their personal lives. Adults can engage in learning projects for their personal pursuits in the same manner, they engage in vocational learning. A new hobby could require one or more lessons to get the learner started. Other adults may engage in a learning project to improve their skills in a hobby they have participated in for some time. An adult may also engage in a scanning-type project in a field that interests them personally. Because SDL includes a range of learning modalities and motivations, it is essential to study SDL in specific contexts. SDL skills and dispositions may be general abilities, but they are likely to manifest differently based on the learning project's circumstances. SDL models are useful to add specificity to both the process and process dimensions.

PPC Model

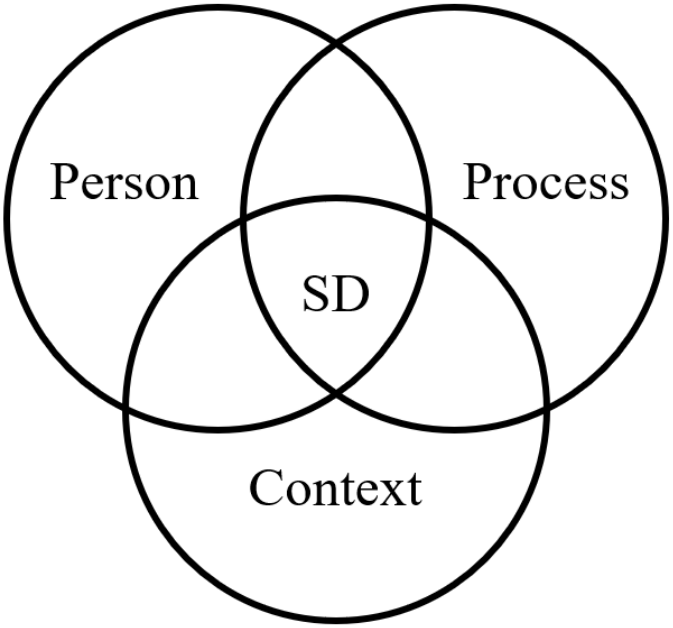
Brockett and Hiemstra (1991) originally proposed the Personal Responsibility Orientation (PRO) model that included both process and personal elements. This model assumes

that to be self-directed, a person needs to use personal responsibility to choose to engage in the learning process. Even in a formal education setting, the learner is responsible for taking the initiative in the process. Once the learner has chosen to participate in learning, the process element becomes important. Learners must decide what they want to learn, choose the appropriate materials, and evaluate their progress. The process components of the PRO model are similar to those described by Knowles and others. The personal element "centers on a learner's desire or preference assuming responsibility for learning" (Brockett & Hiemstra, 1991, p. 24). Brockett and Hiemstra believed learners were on a continuum of ability and desire to engage in SDL.

In 2012, Hiemstra and Brockett updated their model to clarify terminology and redefine the importance of different aspects of SDL. Under the refined "Person, Process, Context" (PPC) model (see Figure 2), personal characteristics and processes are still prominent factors in SDL. The most significant change was that context became a more prominent element. Though they address the context in their earlier writing, Hiemstra and Brockett felt that context was under-addressed previously. In line with other researchers (e.g., Cavaliere, 1992; Spear & Mocker, 1984), the PPC model explicitly addresses the idea that contextual factors are essential in SDL, particularly outside a formal schooling environment. Factors such as finances, technological change, culture, and innumerable others influence what, when, and how adults choose to go about learning.

Figure 2

The PPC Model



Note. Adapted from Hiemstra & Brockett, 2012 under Creative Commons Attribution-NonCommercial

Grow's Model

Grow's (1991) Staged Self-Directed Learning model added structure to the idea that adults varied in their ability to be self-directed in the classroom. Students at the lowest stage depend on the teacher to provide specific guidance about what to learn and how to learn it. These students could be unwilling or unable to exert control over their learning. According to Grow, there was nothing wrong with these students, but ultimately a lack of self-direction could be limiting in the students' lives. Students may also be in different stages in different subjects, in line with the contextual factors of the PPC model. In an ideal situation, teachers could guide students to the fourth and highest stage, where they act as self-directed learners. In these situations, the teacher acts in more of a consultant role while the learner makes most of the decisions about what and how they learn.

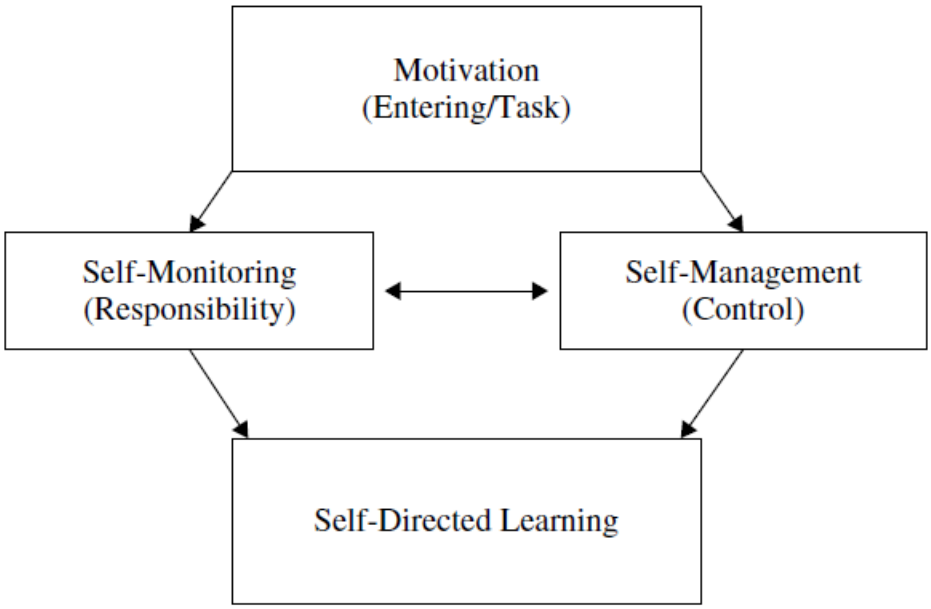
Grow's model highlights several important points. There is again the point that learners exist on a continuum of self-direction, and their abilities and inclinations are likely influenced by the context. Also, Grow attempted to lay out ways teachers could scaffold learners to higher levels of self-direction. A mismatch between the learning environment and the students' stage of self-direction is likely to cause resentment and frustration for both the student and the teachers.

Garrison's "Comprehensive Model"

Garrison (1992) argued that critical thinking and self-directed learning were fundamental concepts within a broader adult education framework. Self-direction was primarily an "external management function," while critical thinking involved separate cognitive functions. In his work on a more comprehensive model of SDL, Garrison (1997) included both internal and external factors. Brockett and Hiemstra's (1991) original model also had internal and external factors, but Garrison critiqued their model because it lacked explicit inclusion of cognitive factors. Garrison's model is shown in Figure 3.

Figure 3

Garrison's Comprehensive Model of Self-Directed Learning



Note. Garrison, 1997

The motivation dimension can be broken down into valence and expectancy and deals with the goals of the upcoming learning project (Garrison, 1997). Adults must have a vested interest in engaging in a learning project before they are willing to participate in SDL. This dimension is similar to the Personal Responsibility component of the PRO model (Brockett & Hiemstra, 1991) and also includes the contextual reasons for entering a learning project (e.g., Clardy, 2000; Spear & Mocker, 1984). The self-management dimension corresponds with external task control, which deals primarily with executing the process aspects of SDL, such as setting goals, finding materials, and implementing learning strategies (Garrison, 1997). Self-monitoring specifically addresses cognitive and metacognitive processes that are necessary for learning. Critical thinking falls under this dimension of the model.

SDL Readiness

Self-directed learning readiness (SDLR) is a more focused concept within the sphere of SDL. Garrison's SDL model highlights the context's breadth, making studying it more challenging. It is also necessary to examine aspects of SDL in context because of the vast difference between a formal education environment and a personal, independent learning project. SDLR is the "attributes, abilities, and personality characteristics necessary for self-direction in learning" (Wiley, 1983). Almost all the previously discussed models have a notion of individual differences that impact a person's self-direction ability. Process models like Knowles' and Stubblefield's assume that the learner is willing to engage in the learning process and can execute the required steps. Other models like Clardy, Brockett and Hiemstra, Grow, and Garrison's provide additional structure around relevant cognitive abilities and personality dispositions.

Empirical research has also shown the need to explore SDLR. Previous researchers found that students differed in their desire for structured educational settings (Wiley, 1983). Students who desired high structure tended to be less successful and less satisfied with low structure courses. The concept of SDLR can help explain some of the differences in satisfaction and success. SDLR is assumed to be on a continuum and does not imply static, innate capabilities. The variety of conceptualizations of SDL are mirrored in the conceptualizations of SDLR. Guglielmino (1977) developed one of the first instruments to measure SDLR. Her research assumed that SDLR existed on a continuum and that attitudes, values, and abilities would ultimately determine whether SDL would occur. Oddi (1986), another prominent SDLR proponent, focused more on working professionals. Oddi's instrument included the same basic

assumptions as Guglielmino. Later researchers such as Brockett and Hiemstra (1991, 2012) and Fisher et al. (2001) came to similar conclusions.

Instruments

Research into SDLR has produced several widely used instruments. As discussed previously, these instruments vary mainly in the personality characteristics that they measure. Even though SDLRS researchers generally agree on the relevance of SDLR and the importance of both abilities and dispositions, they differ in their subcomponents. Three instruments will be addressed: Guglielmino's (1977) Learning Preference Assessment (LPA), Oddi's (1986) Oddi Continuing Learning Inventory (OCLI, and Fisher et al.'s (2001, 2010) SDLR Scale (SDLRS).

Gugliemino's LPA

Guglielmino (1977) designed one of the first instruments to quantify SDLR characteristics. She defined SDLR in broadly as a mix of personal characteristics and capabilities that describe whether a person is willing and able to engage in SDL. The ideas behind SDLR as a specific concept are found throughout most SDL models, even when it is not specifically addressed. Through a Delphi process, Guglielmino developed the Self-Directed Learning Readiness Scale (later renamed the Learning Preference Assessment (LPA)), which has 58 items and eight factors. Those factors include openness to learning opportunities, self-concept as an effective learner, initiative, and independence in learning, informed acceptance of responsibility for one's learning, love of learning, creativity, positive orientation to the future, and ability to use basic study skills and problem-solving skills (Guglielmino, 1977). The pilot study had a reliability of .87 (Cronbach's alpha). The LPA has been widely used since its development, but there have been critiques, notably by Brockett (1985) and Field (1989, 1991). Brockett (1985) argued that the instrument was biased towards learning in a formal setting,

potentially limiting its usefulness in adults with lower formal education attainment. Field (1989, 1991) raised concerns about the factor structure and whether the instrument measures self-directedness instead of a more general love of learning. Other researchers have replicated the original factor structure with high reliability and affirmed the instrument's content validity (e.g., Delahaye & Smith, 1995). The critiques of the LPA are not unique to that instrument and may indicate difficulties in defining and measuring a broad concept like SDLR.

Oddi Continuing Learning Inventory

Oddi (1986) developed the Oddi Continuing Learning Inventory (OCLI) to measure SDLR as a personality construct. Oddi was particularly interested in continuing professional education. After reviewing the literature, the scale was built off three dimensions: proactive versus reactive drive, cognitive openness versus defensiveness, and commitment to learning versus apathy to learning. The final instrument had 24 items and had a standardized coefficient alpha of .875 in a sample of law students, adult education students, and nursing students. Similar to Guglielmino's LPA, some further research supported the three-factor version of the OCLI (Six, 1989), while other scholars found different underlying structures. Harvey et al. (2006) found that a four-factor model fit their population of undergraduate medical students. The challenges with the OCLI are similar to concerns with the LPA. Different factor structures may be more applicable to different contextual settings

Self-Directed Learning Readiness Scale

Fisher et al. (2001) created a new SDLR instrument to address lingering concerns with Guglielmino's LPA. Some researchers have not been able to replicate the eight-factor structure, and there are questions about what the scale actually measures (SDLR or general affinity for learning, as addressed previously. Fisher et al. were also concerned about the cost and

availability of the LPA for continued use. The researchers used a modified Reactive Delphi technique to develop a new scale. The original instrument had items pertaining to nursing education, but they were removed from the final version. The instrument has 40 items and three factors: desire for learning, self-control, and self-management. In a follow-up study in 2010, Fisher and King found support for a modified, 29-question instrument with the same three factors. They recommended future researchers continue to use the complete instrument until more studies could corroborate their findings. Several researchers have found similar results with the 40-item instrument (Bridges et al., 2007; Newman, 2004; Phillips et al., 2015; Şenyuva & Kaya, 2014; Smedley, 2007; Williams et al., 2013). Other researchers have found evidence for a revised version of the original scale. Hendry and Ginns (2009) validated a 35-item version with four factors (critical self-evaluation, learning self-efficacy, self-determination, and effective organization for learning). Williams and Brown (2013) examined the 40, 35, and 29-item versions of the scale and found that the 35-item version had the best fit and the 40-item version had the worst in a sample of 223 undergraduate paramedic students.

The broad concept of SDL exemplifies the importance of contextual and individual differences in how people learn. A common thread through the different characterizations is that people vary in their inclination to engage in SDL and their capacity to carry out a learning project. SDLR provides a framework for exploring those individual differences. The variety of measures and results with those measures indicate that context probably influences how students evaluate themselves on a self-report measure. Adults in a formal education setting likely differ from adults participating in informal learning. The different contexts may be one reason leading to varied results. A person's desire to learn also likely depends on the subject and influences the results in studies where SDLR is used as a predictor.

Empirical Findings about SDL

Research on SDL has taken a variety of tracks. Researchers have looked at the process individuals use to learn on their own, the type of school environment that supports SDL development, the personality traits associated with SDL, and the utility of SDL competencies in and out of school. SDL has been studied with a variety of populations such as undergraduate students (Fisher et al., 2001; Luo et al., 2019; Philips et al., 2015; Smedley, 2007; Sumuer, 2018), students in Massive Open Online Learning Courses (Zhu et al., 2020); and physical therapist practitioners (Bridges et al., 2007).

In line with Grow's stage model (1991), some research has looked at what educational environments can help develop SDL competencies. Problem-based learning has been studied as a way to help students learn how to learn on their own (Choi et al., 2014; Kocaman et al., 2019). It would be normal to expect students to increase various academic competencies during a formal education program. Still, other research has shown that SDL is not always a guaranteed outcome of more schooling (Morris, 2018). Developing SDL requires teaching practices that empower students and where teachers exercise less control over the learning environment. Morris (2019) advocates for an adapting-based learning model where students undertake inquiry projects that challenge them to engage "critically and judgmentally" with the information they encounter. This model requires students to participate didactically with their instructors instead of reinforcing education models where educators control the learning objectives, and students can engage uncritically (Morris, 2019).

Researchers have looked at other constructs that could be vital precursors to effective SDL. A meta-analytic review of 34 studies by Boyer et al. (2014) found that an internal locus of control, motivation, support, and self-efficacy were likely necessary for a learner to engage in

SDL willingly. In addition to these personal barriers for the learner, structural barriers within an educational setting can make SDL more challenging to achieve. Yasmin et al. (2019) looked at the teachers' role in promoting SDL in their students. The participants in their study identified hurdles that educators must overcome to transition from a teacher-directed learning mindset to an SDL model. Some barriers include excessive workload, large student-to-teacher ratios, lack of training, and the prevalence of teacher-centered instructional modes (Yasmin et al., 2019).

SDL has shown promise as an important competency in and out of school. Aspects of SDL, such as self-control (Duckworth et al., 2019) and self-management (Claro & Loeb, 2019), have been associated with higher levels of academic achievement. In another study by Deyo et al. (2010), higher SDL did not have a statistically significant effect on academic achievement as measured by quizzes and tests. SDL was, however, correlated with behaviors typically associated with academic success, such as students meeting more often with their study group, completing pre-work for class, and studying more. This finding could indicate that the measures of academic achievement did not provide enough differentiation or that other factors along with SDL are important for classroom success. The latter interpretation would align with the two-factor theory of critical thinking.

SDL alone is not sufficient for navigating complex information environments. Bliss (2019) proposed that autonomous learners need three related skills: basic computer skills (digital literacy), previous knowledge of content (science literacy in this case), and critical thinking skills (information literacy). The presumption is that adults will be less likely to have a successful learning experience without these three distinct types of skills. Researchers have looked specifically at the relationship between critical thinking and various aspects of SDL. Turan and Koç (2018) examined the relationship between SDL readiness and critical thinking dispositions.

They found a statistically significant relationship between the two constructs, suggesting that SDL readiness may affect students' critical thinking dispositions (Turan & Koç, 2018). Choi et al. (2014) found similar results in a study of nursing students' critical thinking and SDL abilities. These studies indicate that although these constructs are correlated, they are distinct and do not necessarily develop through the same mechanisms in all students.

Relational Reasoning

Relational reasoning (RR) is a measure of fluid intelligence and more complex reasoning abilities (Krawczyk et al., 2010). Alexander and the Disciplined Reading and Learning Research Laboratory (DRLRL) define RR as "recognizing or deriving meaningful relations or patterns between and among pieces of information that would otherwise appear unrelated" (2012). Holyoak and Lu (2020, p. 118) define RR as "reasoning with higher-order, role-governed relations in a manner that approximates the capabilities of a physical symbol system."

In 1890, William James argued that one of the foundational components of human reasoning was the ability to identify similarities and differences in the world around us. Spearman (1927, p. 165) thought that general intelligence equated to a "cognition of relations" and was the foundation of reasoning ability. Work on the importance of RR continued with Cattell (1940), Raven (1941), and Tversky (1977), among others, who all advocated the importance of relational thinking in knowledge and cognition. Today, RR is still generally considered a foundational component of human cognition (Alexander, 2019; Gray & Holyoak, 2019). Four widely accepted RR subcomponents have been studied: analogy, anomaly, antinomy, and antithesis (Alexander & DRLRL, 2012).

Analogical reasoning is the most widely studied of the RR strategies and refers to the ability to recognize the similarities between ostensibly different ideas (Alexander & DRLRL,

2012). Analogies are an important way humans find meaning even among ideas or events that seem dissimilar on the surface. Some researchers also argue that analogous reasoning can help facilitate transfer between subjects (e.g., Salomon & Perkins, 1989). Analogies can also be used as a teaching aid. Providing a tangible abstraction can help students understand a more complex topic.

Anomalous reasoning is the ability to differentiate data that does not fit within the identified pattern or rule set (Alexander & DRLRL, 2012). Inevitably people will encounter information that contradicts information they believe. Anomalous reasoning provides a framework for what people do with conflicting data. Researchers have found that people are not always effective at dealing with anomalous data and updating their beliefs accordingly. Rich and Zaragoza (2016) found that when presented with a story, people struggle to update their beliefs even when anomalous information is pointed out explicitly. The ability to notice and reconcile discrepancies is a fundamental skill, as conflicting information or outright falsehoods are inevitable in life. In some instances, anomalous data can cause a student to rethink their current assumptions, prompting learning (Chinn & Brewer, 1993), while in other cases, students can reject the anomaly and maintain their existing beliefs.

Antinomies are reasonable ideas or data that are categorically incompatible (Alexander & DRLRL, 2012). A commonly cited example of an antinomy in education is the competing theories of Piaget and Vygotsky regarding individual versus social influences in a child's development (Cole & Wertsch, 1996). Antinomial reasoning can allow a person to resolve paradoxes that arise between ontologically distinct ideas. Cole and Wertsch (1996) described how wrestling with the antinomy between the views of Piaget and Vygotsky leads to a more informed understanding of human development. Less research has been done on antinomies as

compared to analogies and anomalies. In their literature review, Dumas et al. (2013) found only one study that dealt with antinomies. Since their review, more education research has included the concept of antinomies, primarily under the RR framenomwork proposed by Alexander and the DRLRL (2012). Despite the overall lack of empirical research, antinomies hold promise in education. Slotta and Chi (2006) found that antinomies were important in understanding complex science topics such as physics. Similarly, Fraher and Grint (2018) argue that antinomial reasoning is important for decision-making in the complex leadership environment exemplified by the U.S. Navy SEALS.

Antithetical reasoning relates to directly contrasting information (Alexander & DRLRL, 2012). Antithetical concepts can include ideas on the opposite end of a continuum, such as hot-cold, or ideas in opposition without an interval between them, such as open-closed (Bianchi et al., 2011b). Antithetical reasoning is also less studied than analogies and anomalies, but like antinomies, they are important to a comprehensive understanding of RR. Antitheses are important for considering counterarguments and thinking about alternative viewpoints (Alexander & the DRLRL, 2012).

Relation to CT

Basic critical thinking abilities are built on cognitive capacity (Bolger et al., 2014). Three major components of cognitive function are the fluid reasoning system, the executive functions system, and declarative memory (Bolger et al., 2014, Diamond, 2013). The fluid intelligence system is relevant to critical thinking because it allows for inductive and deductive reasoning and generating valid inferences (Bolger et al., 2014). Fluid intelligence is related to the critical thinking cognitive skills of analysis, evaluation, inference, and explanation (Facione, 1990).

Under the two-factor theory of critical thinking, RR represents vital cognitive abilities that allow individuals to make reasoned judgments about the world around them. To think critically, a person must be able to analyze and evaluate information and situations. That requires seeing patterns and differences between other situations and information encountered in the past. Understanding differences between current and previous events allows people to respond flexibly to new opportunities and threats. Cognitive abilities like RR are necessary to complement a person's desire to learn new things and think deeply about the world around them.

Measures of Relational Reasoning

The various forms of relational reasoning have been measured in multiple ways. Often, the studies focus on one form at a time. One of the most popular measures of relational reasoning is Raven's Progressive Matrices (RPM) (Raven, 1941). RPM is generally thought of as a measure solely of analogy, which is also the most studied form of relational reasoning. Analogous reasoning has also been studied using verbal comparison in an A:B::C:D format (Wendelken et al., 2008) or visual comparisons in the same A:B::C:D form (Krawczyk et al., 2010). Other dimensions of RR have been investigated in a similar fashion. Researchers have used pictures (e.g., Bianch, Savardi, & Burro, 2011) and verbal comparisons (e.g., Bianchi, Savardi, & Kubovy, 2011) to explore antithetical reasoning. Filik and Leuthold (2008) examined anomalies through pairs of statements such as:

Terry was very annoyed at the traffic jam on his way to work.

He picked up the lorry and carried on down the road.

Qualitative studies have also mapped RR dimensions in interactions (e.g., Dumas et al., 2014). Dumas et al. (2014) looked at the relative use of different dimensions of RR between an expert and novices in the medical profession during team meetings.

A persistent challenge with researching RR has been the lack of a single instrument to measure various manifestations of RR. Alexander et al. (2016) built the Test of Relational Reasoning (TORR) to address this problem. The TORR addresses the four dominant forms of RR in the literature (analogy, anomaly, antinomy, and antithesis) in a single instrument that can be normed for various populations. Using figural problem sets, the TORR accounts for prior knowledge and language abilities (Alexander et al., 2016). These considerations make the TORR a suitable instrument for investigating all four forms of RR. The final version of the TORR contains 32 items, with eight corresponding to each form of RR.

Previous research

Researchers have looked at the impact of RR abilities on a variety of academic skills such as reading (Alexander & DRLRL, 2012), medical education (Dumas et al., 2014), and science, technology, engineering, and math (Murphy et al., 2017). RR has also shown promise in predicting critical thinking abilities (Bolger et al., 2014; Fountain, 2016; Alexander, 2019).

Dumas et al. (2014) studied manifestations of RR in medical education. Their research looked at the quantitative and qualitative use of RR between attending physicians and residents (Dumas et al., 2014). Based on their analysis, the attending physician communicated significantly more examples of RR than was predicted by Chi-square tests (Dumas et al., 2014). The researchers also found a qualitative difference in how RR was expressed. The residents displayed more anomalous reasoning, while the attending physician conveyed most instances of analogical and antinomous reasoning (Dumas et al., 2014). Only about 2% of the RR instances were antithetical, so it was excluded from the analysis (Dumas et al., 2014). The research by Dumas et al. (2014) demonstrates that experts and novices show quantitative and qualitative differences in their capacity for RR. Later research by Dumas and Alexander (2016) found that

individuals with the highest overall RR abilities had consistently greater capabilities in all four subcomponents. Individuals in the midrange for RR ability showed less consistency across the subcomponents, emphasizing that each of the four subcomponents measures a unique ability (Dumas & Alexander, 2016). Although this research did not directly address the role of RR in critical thinking, it highlighted a measure associated with higher-order thinking skills and deeper processing related to critical thinking abilities.

Murphy et al. (2017) provided further evidence on the relationship between RR and CT and how RR abilities can be increased in high school students. The researchers used a teacher-facilitated discussion technique called Quality Talk Science (QT_s), rooted in social constructivist theory (Murphy et al., 2017). Quality Talk was initially designed to build high-level comprehension in a literature class by improving the level of discourse within the classroom (Wilkinson et al., 2010). When QT_s was implemented in chemistry and physics classes, Murphy et al. (2017) documented examples of students engaging in RR as they co-constructed knowledge. The researchers did not measure a change in RR, although there was evidence that engaging in QTs led to a deeper processing of the course material. Further research must examine the link between RR and deeper processing and mechanisms for improving students' RR abilities.

Fountain (2016) sought to show a relationship directly between critical thinking in maternity nursing. Topic knowledge, individual interest, and RR were tested as predictors of critical thinking skills in nurses (Fountain, 2016). Critical thinking was assessed using the Critical Thinking Task in Maternity Nursing measure, while the TORR evaluated RR (Fountain, 2016). Fountain (2016) found that topic knowledge and individual interest were the best predictors of critical thinking, while RR was a small but significant addition to the model's

explanatory power. Even though RR is normally distributed within the general population (Dumas & Alexander, 2016), it had the smallest variation among the variables, with almost 75% of respondents showing a medium ability for RR (Fountain, 2016). This study provides further evidence that exploring the contribution of RR to critical thinking is fruitful. There is also a need to test the relationship between RR and CT in different populations.

Summary

The two-factor theory has been examined as a model for exploring how adults process information online. SDLR and RR represent dispositions and abilities that allow a person to engage in an information environment characterized by Truth Decay fruitfully. COR represents a contextualized examination of how people would interact with information commonly encountered online. The research that was discussed showed how these concepts are essential at the individual and societal levels. Additionally, there is a lack of empirical research dealing with the target population of mid-career, total force USAF and USSF members. The findings of this study will fill gaps in the literature by studying these constructs in a unique population while also exploring their relationships.

Chapter 3: Method

This chapter addresses the research methods used in this study. This chapter will address the purpose of the study, the research design and instruments used, the population and sample, data collection, and analysis procedures. The chapter closes with an examination of the ethical considerations of the study.

Purpose of the Study

The purpose of this non-experimental, quantitative, correlational study was to explore the relative influence of relational reasoning ability and self-directed learning readiness on online reasoning ability in mid-career Total Force USAF/USSF officers and DAF civilians enrolled in the in-residence and asynchronous offerings of a professional military education course. The hypothesized model was built based on prior research and the existing literature. Online reasoning ability was the dependent variable, while SDLR and RR were the independent variables. This study addressed specific gaps in the literature. The findings provide additional nuance about the reasoning skills in this population while also providing an initial study of SDLR and RR. The overall model provided an initial investigation of the relationship between these competencies. SDLR was measured with the previously validated SDLRS (Fisher et al., 2001). The TORR (Alexander et al., 2016) was used to measure relational reasoning, while three previously studied tasks developed by the SHEG (McGrew et al., 2018) were used to assess COR ability.

Problem Statement

The challenge of navigating information online in a saturated media environment filled with falsehoods has been well-documented (e.g., Breakstone et al., 2019; Horn & Veermans, 2019; Marttunnen et al., 2021; Nygren & Guath, 2019). Researchers have found that people

from all sections of society struggle to evaluate the information they encounter online. This struggle has both societal and personal implications. These struggles are despite a prolonged emphasis on critical thinking at all levels of education.

Total Force USAF and USSF officers and DAF civilians represent a distinct segment of the U.S. population. Each member has at least a bachelor's degree, and most participate in a professional military education system that explicitly names critical thinking as a desired learning outcome. Stone (2017) conducted one of the few empirical studies on this population and found that most of the officers in his sample struggled with critical thinking. More research is needed to clarify the extent of this population's reasoning skills and identify potential mechanisms for improvement.

This study investigated the extent of COR skills, SDLR, and RR ability in the population of mid-career USAF and USSF officers and DAF civilians. The study also tested a model for online reasoning skills based on the two-factor theory of CT. The findings filled gaps in the literature by studying these constructs in a unique population while also exploring their relationships.

Research Questions

Research Question 1: Do the chosen COR tasks discriminate between different levels of reasoning ability in mid-career USAF and USSF officers and DAF civilians?

Research Question 2: Does the hypothesized model allow us to reliably predict performance on online reasoning tasks in mid-career USAF and USSF officers and DAF civilians?

Research Question 3: Which of the predictor variables are most influential in predicting performance on online reasoning tasks?

Research Question 4: Do promotion category and level of education predict RR ability among mid-career USAF and USSF officers and DAF civilians?

Research Question 5: Do promotion category and level of education predict SDLR?

Research Design

The study was conducted using a non-experimental quantitative research design using an anonymous, online instrument. This research design was chosen because there was no way to control for or alter the independent variables in the model. The purpose of the research was to understand how well the dependent variables predict the independent variable when measured contemporaneously. The survey included performance tasks, a measure of cognitive ability, and a self-report scale. An anonymous online instrument made the data easier to collect and allowed for honest reflection by the participants. This research design is limited in that it makes it more difficult to establish causality, it can lead to selection and measurement bias, and the participants may answer in a "socially desirable" manner on the self-report scale.

MANOVA was used to assess whether the highest level of education and career field influenced SDLR or RR. MANOVA helps identify significant differences between groups with multiple dependent variables (Mertler & Reinhart, 2017). Hierarchical linear regression was used to analyze the effect of the predictor variables on the dependent variable. Hierarchical regression is an extension of multiple regression, allowing the researcher to use multiple quantitative variables in combination to predict the value of a dependent variable (Meyers et al., 2017). Using hierarchical linear regression allows for predictor variables to be entered in theoretically ordered steps to analyze the relative strength of the different predictors (Meyers et al., 2017). COR ability was chosen as the outcome variable, and SDLR and RR were used as predictor variables. According to the hypothesized model, SDLR was entered first, followed by

RR in step 2. To engage in critical thinking, the person needs to engage in deeper processing of the presented information. In the model, SDLR best accounts for the motivational components necessary for choosing to engage critically. Once the person has chosen to engage deeply with the information, RR ability would likely influence how well they can find meaningful relations within the information.

Population and Sample

Sample size

The minimum required sample size was assessed using multiple factors. For multiple regression Stevens (2001) recommends at least 15 cases per predictor. Tabachnick and Fidell (2007) provide more conservative formulas. For testing multiple correlations, they recommend a sample size greater than $50 + 8 * k$ (k is the number of IVs). To test individual predictors, they recommend a sample size greater than $104 + k$. The hypothesized model includes four predictors making the minimum recommended sample sizes 60, 98, and 108, respectively. An a priori power analysis was also conducted using G*Power 3.1.9.7 (Faul et al., 2007). Medium effect size was chosen in line with previous research. Fountain (2016) found a moderate effect size predicting critical thinking ability using relational reasoning as one of the predictors. Based on an α of 0.05 and a power of 0.80, the required sample size to detect a medium effect was 85.

The general population for this study is mid-career USAF/USSF officers and DAF civilians. DAF civilians comprise a small percentage of students in the in-residence PME course (42 out of 1,776 in-residence students; 2.4%). Civilian students make up almost 15% of students enrolled in the asynchronous course (480 out of 3,237 students; 14.8%). The make-up of each in-residence professional military education class generally represents the demographics of the entire Air Force. The total population of officers is 64,873, and the average age is 35 (Air

Force's Personnel Center, 2021). In the final "clean" dataset, the average age was 33.8. Race and ethnicity for the USAF and the sample are summarized in Table 1, which shows that the sample approximates the race/ethnicity of the USAF and USSF. Table 2 summarizes gender for the USAF compared with the completed sample. However, because the sample is so small, the number of participants in racial and ethnic minority groups is minimal. Table 2 shows that the final sample contains a much larger percentage of women than the USAF and USSF. This sample should not be considered representative of the USAF and USSF or the population of mid-career officers and DAF civilians.

Table 1

Race/Ethnicity of Air Force Total Force Officers Compared to the Sample

	ANG Officers [a]		AFR Officers		AD Officers		AD O-3		Sample	
	#	%	#	%	#	%	#	%	#	%
White	13389	86.41%	11386	81.09%	49970	78.20%	15834	76.62%	53	77.14%
Black	706	4.56%	883	6.29%	3939	6.16%	1341	6.49%	1	1.43%
AIAN [c]	76	0.49%	62	0.44%	317	0.50%	107	0.52%	1	1.43%
Asian	473	3.05%	593	4.22%	3325	5.20%	1197	5.79%	6	8.57%
NHPI [d]	83	0.54%	78	0.56%	321	0.50%	117	0.57%	0	0.00%
Two or more	768	4.96%	285	2.03%	1946	3.05%	681	3.30%	5	7.14%
Unknown	0	0.00%	755	5.38%	4084	6.39%	1389	6.72%	1	1.43%
TOTAL[e]	15495	100.00%	14042	100.00%	63902	100.00%	20666	100.00%		
Hispanic	905	5.84%	890	6.34%	4717	7.38%	1640	7.94%	2	2.86%
Not Hispanic	13640	88.03%	10514	74.88%	49080	76.81%	16626	80.45%	0	0.00
Unknown	950	6.13%	2638	18.79%	10105	15.81%	2400	11.61%	0	0.00
TOTAL[e]	15495	100.00%	14042	100.00%	63902	100.00%	20666	100.00%	69	100%

Note. [a] Data for the Air National Guard is not broken down by rank. [b] Data for the Air Force Reserves is not broken down by rank. [c] American Indian, Alaska Native. [d] Native Hawaiian, Pacific Islander. [e] In the survey, race and ethnicity were combined into a single question. The total for the sample includes all 69 participants

Table 2

Air Force Total Force Officers' Gender Compared to the Sample

	ANG Officers [a]		AFR Officers [b]		AD Officers		AD O-3		Sample[d]	
	#	%	#	%	#	%	#	%	#	%
Men	12463	80.43%	10265	73.10%	49970	78.20%	15578	75.4%	41	59.42%
Women	3032	19.57%	3777	26.90%	13932	21.80%	5088	24.6%	26	37.68%
Unknown	0	0.00%	0	0.00%	0	0.00%	0	0.00%	2	2.80%
TOTAL	15495	100%	14042	100%	63902	100%	2066	100%	69	100%

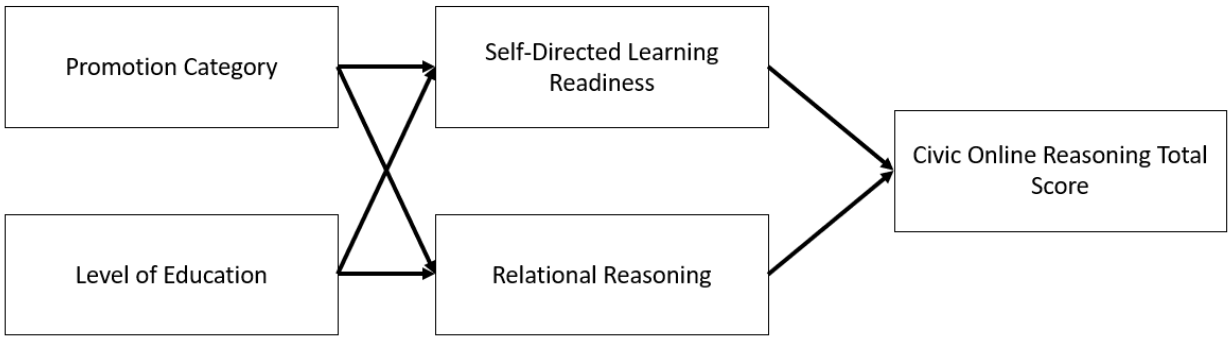
Note. [a] Data for the Air National Guard is not broken down by rank. [b] Data for the Air Force Reserves is not broken down by rank. [c] Gender was reported for each service component as either man or woman. [d] In this survey, gender was collected through an open response question.

Variables

The hypothesized model was built on the two-factor theory of critical thinking and that theory's ability to predict career success in the Air Force. The hypothesized model is shown in Figure 4.

Figure 4

Hypothesized Model



The independent variables include education, promotion category, self-directed learning readiness, and relational reasoning ability.

Education

All of the participants had at least a bachelor's degree. Additional formal education beyond an undergraduate degree may predict higher SDLR and RR ability.

Promotion Category

Different career fields within the Air Force have different career progressions and focus areas. These different career paths likely emphasize different reasoning and self-direction levels. Individuals are more likely to develop reasoning skills and SDL dispositions when they are practiced on the job. Due to the large number of career fields, promotion categories were used for analysis. The USAF groups similar career fields for promotion purposes. Career fields

within each promotion category have similar leadership responsibilities and professional experiences.

SLDR

SDLR in this study was made up of self-control, self-management, and desire for learning. This variable represents critical thinking dispositions under the two-factor theory of critical thinking. Individuals high in SDLR should be more inclined to seek learning opportunities and practice the higher-order thinking skills required by COR.

Relational Reasoning Quotient (RRQ)

Relational reasoning is made up of analogy scores, anomaly scores, antinomy scores, and antithesis scores. Scores from each subcomponent are combined to create a single RR score. RRQ is a scaled version of the score with a mean of 100 in the original sample, similar to IQ, to aid analysis. This variable represents critical thinking skills under the two-factor theory of critical thinking and is a measure of fluid intelligence. Individuals who are high in RR have the cognitive ability to find connections and dissimilarities in the stream of online information, which should contribute to higher COR skills.

COR Ability

The dependent variable in this study was COR ability. The COR ability variable was comprised of the participant's total score on the COR tasks. This variable represented a measure of critical thinking ability based on the two-factor theory of critical thinking. Success on the COR tasks required both critical thinking skills and dispositions. Participants must seek out information and provide reasoned judgments about claims that are found online.

Instrumentation

COR

Some of the skills generally agreed upon for CT are tested by COR. Participants must be able to analyze and evaluate information typically found online. The original tasks were tested on middle and high school students (Horn & Veermans, 2019; McGrew et al., 2018). Follow-up studies expanded the population to include college-age students as well. The tasks have been used in other research studies and in media literacy education in classrooms in other western countries as well (Horn & Veermans, 2019). The SHEG has created numerous tasks, and new ones could be developed by the researchers and pilot tested to ensure a similar difficulty level. The tasks have rubrics associated with them, and the tasks have previously been used in an online instrument. The procedures for this survey will be the same as those used previously. The use of multiple raters enhanced reliability. These raters independently scored the participants' answers according to the rubrics and adjudicated any conflicting ratings. Content validity from the tasks came from the fact that they are real examples of common information on the internet. Criterion validity was enhanced through the use of rubrics which identified the standards that represent different skill levels.

The principal investigator recruited a second rater with undergraduate teaching experience to obtain interrater agreement. The second rater was provided with the tasks and the rubrics created by the SHEG. Because of the small sample size, both raters scored every task for all participants. To provide an initial baseline, both raters independently scored each task for 12 participants. The two raters discussed the discrepancies, and a final score was mutually decided. Each rater then scored the remaining tasks for the COR task sample. The raters differed on 61 out of 360 possible scores, leading to an interrater agreement of 84%. The raters discussed each discrepancy, and the final scores were agreed upon by both raters.

SDLRS

Self-directed learning readiness was measured using the 40-item Self-Directed Learning Readiness Scale (SDLRS) developed by Fisher et al. (2001). The original instrument had items pertaining to nursing education, but they were removed from the final version. The instrument uses a five-point Likert scale. In concert with SDL literature, the SDLRS has three components, self-management, self-control, and desire for learning (Fisher et al., 2001; Fisher & King, 2010). The SDLRS was developed by Fisher et al. (2001). In the original pilot study, Cronbach's α for the total scale was .92, for self-management (13 items) Cronbach's α = .86, desire for learning (12 items) Cronbach's α = .85, self-control (15 items) Cronbach's α = .83. The instrument's content validity is supported by the Delphi method used during the instrument's development and from its foundation in the major themes of SDL research (Fisher & King., 2010).

In Chapter 2, a 29-item and 35-item version of the SDLRS were discussed at length. Participants were administered the 40-item version, but the two alternate versions were also analyzed since the existing questions were not modified and no questions were added. Reliability was tested with the sample. Contextual factors may influence which version of the SDLR is most appropriate for different samples.

Test of Relational Reasoning (TORR)

The TORR was developed by Alexander et al. (2016) and measures four forms of relational reasoning. The TORR contains 32 items and has been calibrated for use with adolescents and adults (Dumas & Alexander, 2018). Participants were presented with figural problem sets and four possible answers. Researchers gave the test at two different times during pilot testing for the TORR. The Cronbach's α was .84 at Time 1 and .82 at Time 2 (3 weeks later) (Alexander et al., 2016). This indicates good reliability. The instrument's content validity is built on other research on relational reasoning. The four types of relational reasoning were

identified, and then a group of scholars created individual items that met the competency being tested (Alexander et al., 2016).

Procedures

Recruitment: Participants were recruited from the in-residence and asynchronous versions of an Air Force PME course. The student population in the course was mid-career USAF and USSF officers and DAF civilians. The in-residence course is 5-weeks long and covers much of the same material as the asynchronous course. Students who cannot attend the in-residence course are eligible to complete the asynchronous course instead. Participants were recruited from three iterations of the in-residence course between December 2021 and April 2022. All 3,237 students enrolled in the asynchronous course as of March 22, 2022, were invited to participate.

In-residence students: Potential participants were recruited through the in-residence course's online learning management system (LMS) and flyers that were distributed to the students through their instructors. Announcements were placed in the LMS by the course administrator. Students were also sent a recruitment message through the LMS messaging system by the principal investor. The flyers, announcements, and messages directed willing participants to an anonymous link to the survey in Qualtrics. All the potential participants had access to the school's LMS. The flyer was distributed during the first week of the course at the same time the initial recruitment messages were posted in the LMS. Halfway through the course, a follow-up message was sent through the LMS, and the final recruitment message was sent during the last week.

Asynchronous students: Students in the asynchronous course received recruitment emails through the school's messaging system. Students received three recruitment messages spaced approximately 1week apart.

Participation was 100% voluntary, and all participants were over 18 years old. U.S. military students and DAF civilians were eligible to participate based on their enrollment in the professional military education course. The student population for both courses is military officers who generally have between four and seven years of military service and DAF civilians of equivalent rank and experience. Participants who completed the survey had the option to receive a $5 Starbucks gift card as compensation. Students who wished to receive the gift card were directed to a separate survey where they could enter an email address.

The web-based questionnaire was built and hosted on Qualtrics and was expected to take approximately 60 minutes. The survey had three parts. Participants responded to three Civic Online Reasoning tasks; next, they completed the Test of Relational Reasoning. Finally, they completed the Self-Directed Learning Readiness Scale. The three parts were in the same order for all participants. This survey was ordered so that each subsequent instrument required less mental effort. Individual items within each survey section were randomized to minimize systemic error due to order effects. Students were advised to spend approximately 5-8 minutes completing the COR tasks. The TORR was expected to take about 35 minutes, while the SDLRS was expected to take 5-7 minutes.

Due to the time commitment to complete the entire survey, it was possible that participants would lose interest or motivation at the end of the survey. The authors of the SDLRS included four negatively worded items to minimize participants providing similar responses without actively reading each item (Fisher et al., 2001). Two instructed response

items were added for this study. These items asked the participant to provide a specific response to that item (e.g., Please select "Somewhat agree" for this item). Some prior research indicates that attention checks can lead to more attentive participation by respondents (Hauser & Schwarz. 2015). Six participants failed both of the instructed response questions either by answering incorrectly or not answering those items.

Students who completed all three COR tasks were included in the analysis of RQ 1. Students who only partially completed the COR tasks were excluded. These tasks required effort by the students to provide a response representative of their capabilities. Their responses were still scored, and subsequent analysis showed that these participants demonstrated low proficiency. Because their performance may not have been representative of their true abilities, they were excluded to avoid distorting the results.

The leadership at the school and the Air Force Human Research Protection Office approved the data collection procedures. The survey did not ask for directly identifying information, and the survey was also set to anonymize responses to avoid collecting IP addresses, location data, and contact info.

Internal validity

The two-factor theory of critical thinking formed the basis of the model. Scholars have researched this theory for over 30 years (Alexander, 2014; Ennis, 1985; Facione, 1990; Paul & Elder, 1998). Each component of the hypothesized model has been previously researched, and the instruments have been previously validated.

COR is built on research about motivated reasoning and political information conducted by Kahne and Bowyer (2016). COR has also been linked to critical thinking skills through research about misinformation (Horn & Veermans, 2019), and it is operationalized as a measure

of critical thinking in this study. The skills required to evaluate and verify information align with generally accepted critical thinking constructs (Alexander, 2014; Ennis, 1985; Facione, 1990; Paul & Elder, 1998). The COR tasks used are measures of what participants actually do when faced with information online instead of questions about intentions in hypothetical situations.

SDL readiness, as used in this study, is also based on foundational research on self-directed learning. The SDLRS was developed through a 2-stage Reactive Delphi technique (Fisher et al., 2001). Eleven experts who had previously done research and taught on SDL helped identify important constructs for the instrument (Fisher et al., 2001). The SDLRS has been used in populations of undergraduate students (Fisher et al., 2001; Luo et al., 2019; Philips et al., 2015; Smedley, 2007; Sumuer, 2018); students in Massive Open Online Learning Courses (Zhu et al., 2020); and physical therapist practitioners (Bridges et al., 2007). Luo et al. (2019) found that scores on the SDLR were positively correlated with problem-solving ability in undergraduate nursing students.

Relational reasoning has been researched in relation to problem-solving (Dumas et al., 2016, Jablansky, 2020), critical thinking and individual interest in maternity nursing (Fountain, 2016), and expertise in medical education (Dumas et al., 2014). Previous research has identified the importance of cognitive abilities in making social judgments (Murphy & Hall 2010) and correcting previous judgments based on false information (De keersmaecker & Roets, 2017). People with higher relational reasoning ability may be better able to parse data and weed out low-quality sources and arguments.

External validity

This study was intended to generalize to the population of early-mid career officers. The study may provide insight into the enlisted force but would not necessarily be able to account for differences in the career development track even when education and promotion category are aligned. The findings may have some relevance to officers in other branches of service. However, different service cultures will add confounding variables that will be difficult to account for without additional research. The findings may also be interesting to the young, working professional population at large, but the dynamics of Air Force and Space Force service will likely significantly influence the findings and limit some direct application to the civilian population.

Data Collection and Management

Identical surveys were built in Qualtrics, one for the in-residence students and one for the asynchronous students. The separate surveys aided in tracking respondents based on which version of the course they were enrolled in. After the survey was closed, the datasets were combined before analysis. The Civic Online Reasoning tasks were graded based on rubrics developed by the Stanford History Education Group. A second rater was trained, and they scored each of the COR tasks independently of the principal investigator. After all tasks were scored, the ratings were compared, and discrepancies were discussed until there was agreement. The additional rater only had access to the COR responses and an anonymized respondent ID that was not linked to any potentially identifying information about the participants.

Data Analysis Procedures

The statistical analyses were conducted using R version 4.1.2. The data were screened according to the procedures outlined by Mertler and Reinhart (2017). The dataset was checked for missing data, multivariate outliers, linearity, normality, and homoscedasticity. Participants

who completed all three COR tasks with sufficient effort were retained for analysis of RQ1. Only participants who finished the survey were included for analysis of the RQs 2-5. Before further analysis was conducted, MANOVA was used to determine if there was a significant difference between the in-residence and the asynchronous participants. Descriptive statistics were used to answer the first research question to determine if the scores on the COR tasks differentiated participants within the sample. Research questions 4 and 5 were analyzed using MANOVA.

Research questions 2 and 3 were analyzed using hierarchical linear regression. COR score was used as the dependent variable. All SDLR subcomponent scores were added in the first step, while RR ability was added in the second step. This enabled the analysis of the relative contributions of the predictors.

Ethical Considerations

There are minimal ethical concerns with this study. All of the participants were adults, and participation was voluntary. Informed consent was provided at the start of the survey, and participants had the option of exiting the survey at any time. There were minimal risks to the participants. If someone had access to the demographic data and a detailed course roster, they might identify some individual participants. The study data was kept separate from information about students in the class. There were no other expected risks or discomforts. The survey data was collected through Qualtrics, and the data were stored electronically on the hard drive of a password-protected laptop. Backup storage of the data used Box cloud storage. At the end of the primary survey, participants who chose to receive a gift card were directed to a second survey. The second survey only collected email addresses and was not linked to the information collected in the main survey.

Chapter 4: Results

This chapter reports the results of the methods outlined in Chapter 3, informed by the theoretical analysis from Chapter 2. First, this chapter reviews the problem statement and the research questions for this study. Before any subsequent analyses, each study variable was analyzed using a MANOVA to see if there were significant differences between participants in the in-residence course and the asynchronous version. Next, the results of data screening and the assumptions of multivariate statistics will be discussed. The chapter concludes with the results of the statistical analysis for each of the research questions. Hierarchical linear regression was used to test the full model, while MANOVAs were used to test whether the highest level of education or promotion category predicted SDLR or RR.

Problem Statement

The challenge of navigating information online in a saturated media environment filled with falsehoods has been well-documented (e.g., Breakstone et al., 2019; Horn & Veermans, 2019; Marttunnen et al., 2021; Nygren & Guath, 2019). Researchers have found that people from all sections of society struggle to evaluate the information they encounter online. This struggle has both societal and personal implications. These struggles are despite a prolonged emphasis on critical thinking at all levels of education.

USAF and USSF officers represent a distinct segment of the U.S. population. Each officer has at least a bachelor's degree, and most participate in a professional military education system that explicitly names critical thinking as a desired learning outcome (Chairman of the Joint Chiefs of Staff, 2020). Stone (2017) conducted one of the few empirical studies on this population and found that most of the officers in his population struggled with critical thinking.

More research is needed to clarify the extent of this population's reasoning skills and identify potential mechanisms for improvement.

This study will investigate the extent of COR skills, SDLR, and RRQ in the population of mid-career USAF and USSF officers. The study will also test a model for online reasoning skills based on the two-factor theory of CT. The findings will fill gaps in the literature by studying these constructs in a unique population while also exploring their relationships.

Research Questions

Research Question 1: Do the chosen COR tasks discriminate between different levels of reasoning ability in mid-career USAF and USSF officers and DAF civilians?

Research Question 2: Does the hypothesized model allow us to reliably predict performance on online reasoning tasks in mid-career USAF and USSF officers and DAF civilians?

Research Question 3: Which of the predictor variables are most influential in predicting performance on online reasoning tasks?

Research Question 4: Do promotion category and level of education predict RR ability among mid-career USAF and USSF officers and DAF civilians?

Research Question 5: Do promotion category and level of education predict SDLR?

Data Screening

Differences Between Learning Modalities

Study participants were recruited from in-residence and asynchronous versions of a PME course. The in-residence course had a higher percentage of active-duty USAF and USSF students, while the asynchronous course had more ANG, AFR, and DAF civilian students. Three MANOVAs were used to ensure no statistically significant differences between these groups of

participants on the factors for each version of the SDLRS, RRQ, and COR. For the 40-item version of the SDLRS, no statistically significant differences were found based on course modality, Pillai's Trace = .043, F (5, 63) = 0.572, p = .721. The 29-item version of the SDLRS also did not show statistically significant differences based on course modality, Pillai's Trace = .040, F (5, 63) = 0.522, p = .758. Finally, the 35-item version of the SDLRS, showed no statistically significant differences based on course modality Pillai's Trace = .084, F (6, 62) = .945, p = .470. Participants from both courses were considered equivalent in further analyses.

Missing Data

After confirming there were no statistically significant differences between groups, the data were screened for completion. During the demographic and SDLR portions, participants were not required to answer each item. If they attempted to navigate to the next page with unanswered items, they received a prompt and were given the option to complete all items. Participants did not have the option to skip items in the COR and TORR portions of the survey. This limited missing data to participants who opted not to finish the survey, participants who skipped demographic items, and students who missed items on the SDLRS. Two considerations were given for completion. Participants who completed each of the COR tasks were retained for research question 1 analysis. Participants who completed the entire survey were considered for analysis of research questions 2-5. In total, 251 eligible participants registered a response in Qualtrics. Missing data is broken down by survey component in Tables 3 and 4.

Table 3

Missing Data on Demographic Items

	Missing	Percent	Total
Age	12	4.78%	251
Gender	12	4.78%	251
Race/Ethnicity	11	4.38%	251
Level of Education	11	4.38%	251
Career Field	15	5.98%	251

Table 4

Missing Data on Study Variables

	Missing	Percent	Cumulative Total	Total
No Study Variables	113	45.02%	113	251
Partial COR	37	14.74%	150	251
COR Tasks	20	7.97%	170	251
COR & TORR	3	1.20%	173	251
COR & TORR & SDLRS	78	31.08%	251	251

COR Tasks

The participant flow through the study is presented in Figure 5. A total of 101 participants (101/251, 40.2%) completed all 3 COR tasks. The COR tasks required the students to provide a response indicative of their actual abilities. Analysis of the COR task responses revealed six participants whose responses were insufficient to score fairly. For example, in the article analysis task, participants were asked whether the linked article was a good source of information about the minimum wage. Participant #244 answered, "No." The second article analysis question prompted the participants to explain their reasoning, and participant #244 responded, "No." Participant # 244 answered both Researching a Claim tasks "no." Participant #249 answered the first question about the minimum wage article "Yes." For the second part of the task, they wrote, "Easy to read." These responses would have been scored as beginning but were deemed more revealing of the student's interest in completing the tasks than their actual

reasoning ability. The final sample for COR task analysis included 95 participants (37.8%) who successfully completed all three tasks with sufficient effort.

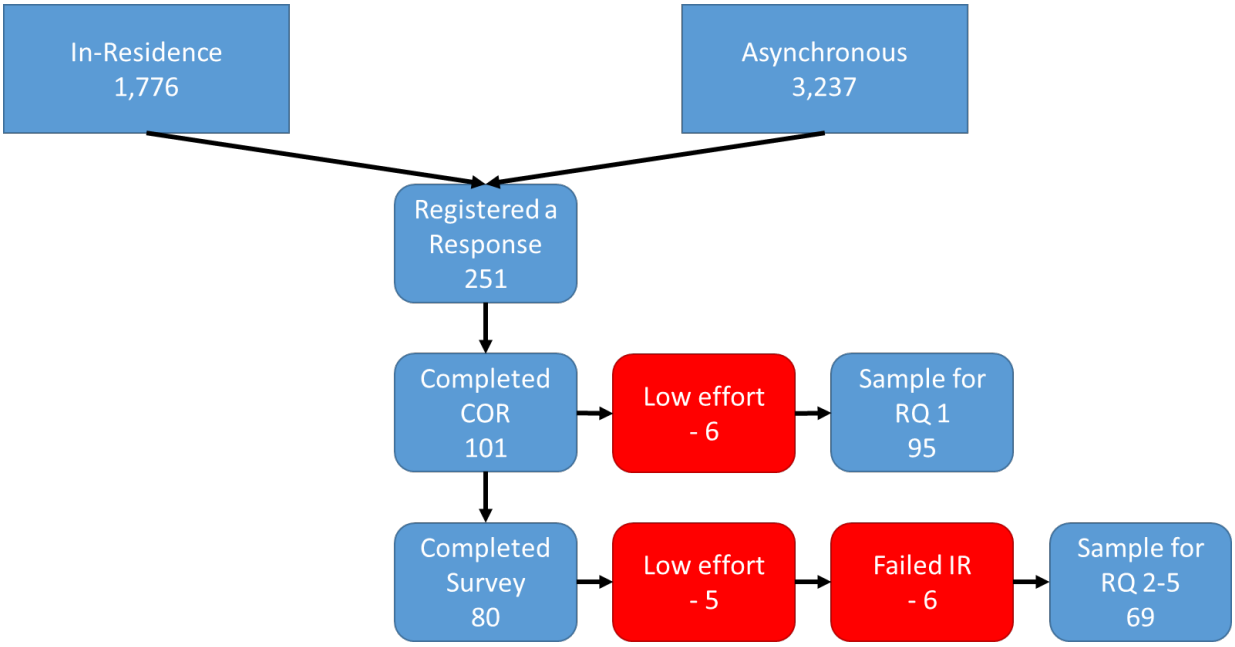
Complete Survey

Out of the 101 participants who completed the COR tasks, 80 (80/251, 31.9%) completed the entire survey. Five participants who completed the entire survey were from the group of low-effort participants, and they were removed from further analysis. Two instructed response items were included in the SDLRS portion of the survey. Those questions directed the participant to provide a specific response (e.g., Please select "Somewhat agree" for this item). There were 6 participants who failed both of the instructed-response questions either by answering incorrectly or not answering those items. Further analysis determined that none of these participants were univariate or multivariate outliers or otherwise notable cases, and they were removed from the data set. The final sample for analysis of research questions 2-5 was 69 (27.5.%).

In the final data set, missing data was not a concern. Of the 69 participants, 67 answered each item in the survey. Only two participants had missing data; participant 16 opted not to provide their gender, and participant 207 opted not to provide their age and gender. Neither of these variables was used in the analysis, and no further action was taken.

Figure 5

Participant Flow through Study



Visual inspection for accuracy and plausibility

The univariate descriptive statistics were analyzed for accuracy and plausibility. The minimum, maximum, median, and standard deviations for each of the study variables are shown in Table 5. Visual inspection of these values showed that the data was plausible and did not indicate inaccurate data entry or coding. Additionally, these values are reasonable based on the results reported by other researchers using these instruments.

Table 5

Descriptive Statistics

Measure	*M*	Std. Dev.	Minimum	Maximum
COR	2.21	1.77	0	7.5
RRQ	100.59	12.41	76	126
SDLRS 40-Item[a]	168.71	16.90	126	200
Desire for Learning (DFL)	52.26	5.5	39	60
Self-Control (SC)	65.42	5.35	54	75
Self-Management (SM)	51.03	7.90	30	65
SDLRS 29-Item[b]	117.49	12.64	86	140
DFL	38.55	4.51	27	45
SC	43.87	3.75	36	50
SM	35.07	6.07	18	45
Revised SDLRS 35-Item[c]	148.68	14.45	111	175
Critical Self-Evaluation (CSE)	21.94	2.65	15	25
Effective Organization for Learning (EOL)	30.29	5.58	15	40
Learning Self Efficacy (LSE)	80.32	6.75	65	90
Self-Determination (SD)	16.13	2.32	10	20

Assumptions of Hierarchical Linear Regression

The primary data analysis was conducted with hierarchical linear regression. The statistical assumptions required by the general linear model were tested to ensure valid results. Those assumptions address normality, linearity, homoscedasticity, and independence of errors (Meyers et al., 2017). The data were also checked for univariate and multivariate outliers, and multicollinearity. The assumptions were checked using R.

Univariate Outliers

Univariate outliers are extreme values for one variable based on the rest of the values in the sample. The values can carry excessive weight in statistical calculations and bias the regression results. Univariate outliers were examined using boxplots and calculating *z*-scores for each study variable. For the research question 1 dataset, COR scores for the participants who completed all three tasks ($n = 95$) were examined for outliers. COR score, RRQ, and all three

SDLRS versions and each subcomponent were examined for the complete data set (n = 69). Two participants had missing data for items on the SDLRS. The participants with missing data had also failed the attention check items and were included to examine whether there was anything noteworthy about their cases before a deletion determination was made. Upon examination, it was decided that these participants were not outliers or otherwise unique cases, and they were removed from further analysis. Participants with z scores exceeding ± 2.5 were considered outliers (Mertler et al., 2017). Table 6 shows the outlier analysis for the COR analysis data set, and Table 7 shows the outlier analysis for all the study variables.

Table 6

Outlier Analysis for COR Tasks

Variable	Participant	Value	z Score
COR Score (n = 95)	16	6.5	2.61
	127	7.5	3.21
	171	7	2.91

Table 7

Outlier Analysis for Study Variables for Full Models

Variable	Participant	Value	*z* Score
COR Score (*n* = 69)	16[b]	6.5	2.43
	127	7.5	2.99
	171	7	2.71
RRQ (*n* = 69)	No outliers detected	N/A	N/A
SDLRS 40 (*n* = 69)	128[a]	126	-2.53
DFL (*n* = 69)	No outliers detected	N/A	N/A
SC (*n* = 69)	No outliers detected	N/A	N/A
SM (*n* = 69)	40[b]	33	-2.28
	128	30	-2.66
SDLRS 29(*n* = 69)	No outliers detected	N/A	N/A
DFL (*n* = 69)	51	27	-2.56
SC (*n* = 69)	No outliers detected	N/A	N/A
SM (*n* = 69)	40	18	-2.81
	128	19	-2.65
Revised SDLRS[c]	128[a]	111	-2.61
CSE	40[a]	15	-2.62
	128[a]	15	-2.62
EOL	40	15	-2.74
	128	16	-2.56
LSE	No outliers detected	N/A	N/A
SD	165	10	-2.64

Note. [a] Participant only identified as an outlier by *z* score. [b] Participant only identified as a outlier on boxplot.

After the participants were screened for univariate outliers, the data set was checked for multivariate outliers using Mahalanobis distance (Mahalanobis, 1936). The Mahalanobis distance was calculated three times using COR score, RRQ, and each of the three versions of the SDLRS separately. The Mahalanobis distance was evaluated using .001 as the threshold (Mertler et al., 2017). Based on this criterion, no multivariate outliers were identified. Table 8 shows Mahalanobis scores for the participants who failed the instructed-response items. None of these participants were identified as multivariate outliers.

Table 8

Mahalanobis Distance for Excluded Cases

Participant #	40-Item SDLRS		29-Item SDLRS		35-Item SDLRS	
	Mahalanobis Distance	*p*	Mahalanobis Distance	*p*	Mahalanobis Distance	*p*
96	1.278	.865	1.659	.798	4.643	.326
142	5.926	.205	6.127	.190	7.694	.103
172	3.754	.440	3.835	.429	4.207	.379
188	3.886	.422	2.931	.569	5.060	.281

Note. Participant 94 and participant 243 had missing values on the SDLRS. They were excluded from the Mahalanobis distance analysis.

The combined univariate and multivariate outlier analysis did indicate that any participants should be removed from further analysis. The two outlier scores on the COR tasks were the two highest scoring participants but were within the range of plausible outcomes. Additionally, removing those cases would have artificially lowered the mean COR performance and deleted two participants that demonstrated the highest level of proficiency on the key dependent variable. Participant 128 was flagged as a potential outlier on several aspects of the three versions of the SDLRS. Further examination of participant 128 showed above-average scores on COR and RRQ. The participant had low scores on self-management (40 item SDLRS, 29 item SDLRS) as well as critical self-evaluation and effective organization for learning (Revised SDLRS). These values are still within the expected range for the variables and did not raise any specific concerns about their inclusion. The potential outliers were not removed because of these factors and because the number of potential outliers was small.

Normality

The normality assumption was examined using histograms, Q-Q plots, and statistical tests. Multivariate normality was examined using Mardia's (1970, 1974) normalized estimate of

multivariate kurtosis. Data transformations were considered as appropriate to correct violations of the normality assumption.

Univariate Normality

Histograms were visually examined for potential violations of normality (Figure 6). Several variables showed potential normality violations based on the shape of the histograms. The Q-Q plots also showed potential violations (Figure 7). Statistical analysis was conducted using Shapiro-Wilk normality tests and tests of skewness and kurtosis. The results of these analyses are shown in Table 8. Four variables showed violations of the normality assumption at the .01 level (Tabachnick & Fidell, 2007): COR score, DFL (40-item SDLRS), DFL (29-item SDLRS), CSE (Revised SDLRS), and LSE (Revised SDLRS). These violations of normality were considered serious enough that data transformations were used to modify the variables.

Table 9

Normality Analysis for Study Variables

Measure	Shapiro-Wilk		Skewness	Kurtosis
	Statistic	*P*		
COR	0.912	.001**	.974	0.723
RRQ	0.980	.013	0.172	-0.820
SDLRS 40	0.975	.188	-0.367	-0.523
DFL	0.936	.002**	-0.608	-0.613
SC	0.978	.271	-0.128	-0.685
SM	0.973	.135	-0.462	-0.097
SDLRS 29	0.967	.068	-0.480	-0.35
DFL	0.941	.003**	-0.649	-0.412
SC	0.967	.062	-0.143	-0.874
SM	0.961	0.032	-0.649	0.199
Revised SDLRS	0.975	.188	-0.374	-0.504
CSE	0.914	< .001***	-0.600	-0.369
EOL	0.968	.078	-0.566	0.098
LSE	0.940	.002**	-0.558	-0.535
SD	0.968	.069	-0.131	-0.449

Note. Significance codes: *** $p < .001$. ** $p < .01$.

Figure 6

Histograms for Study Variables that Violated Normality Test

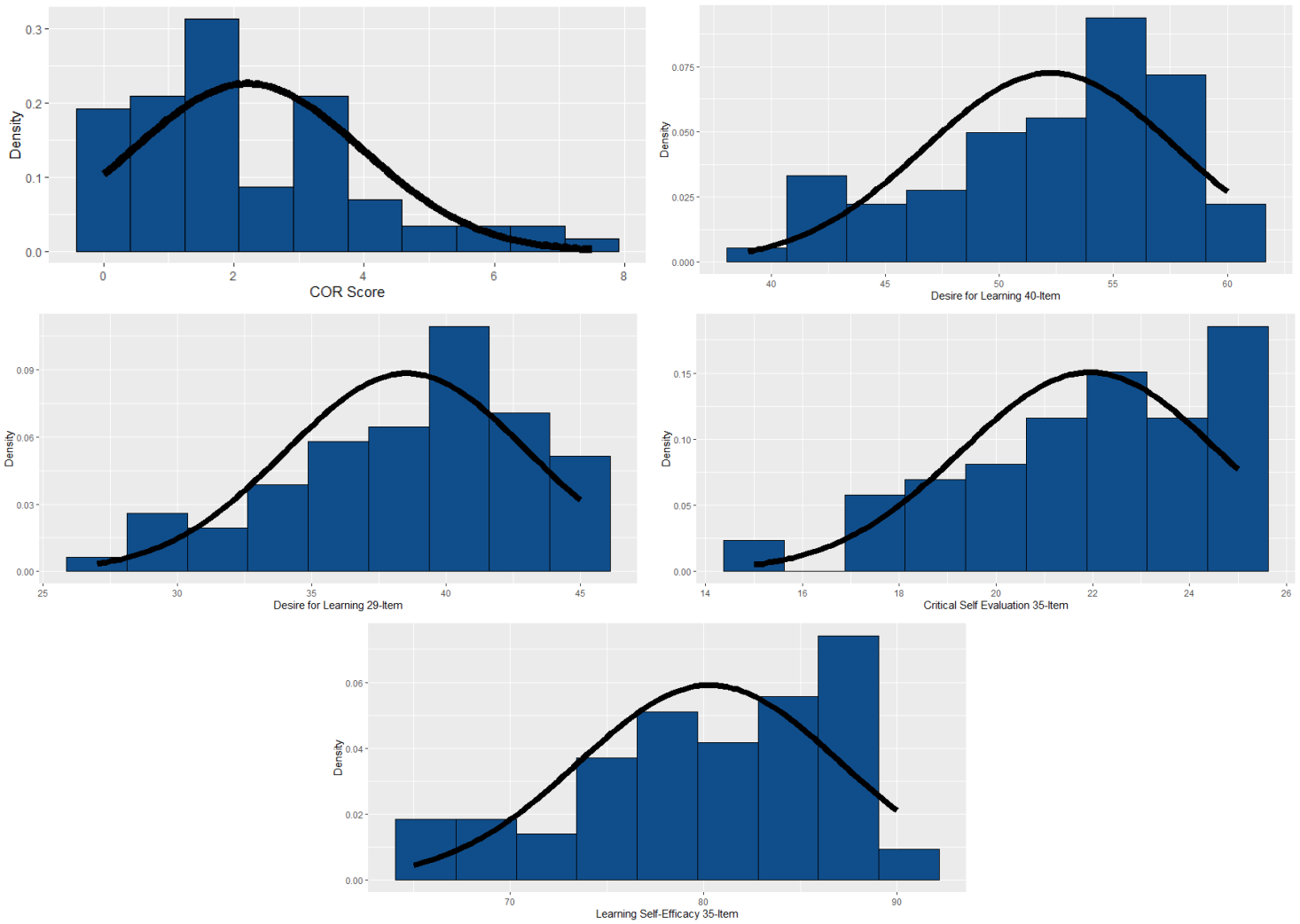
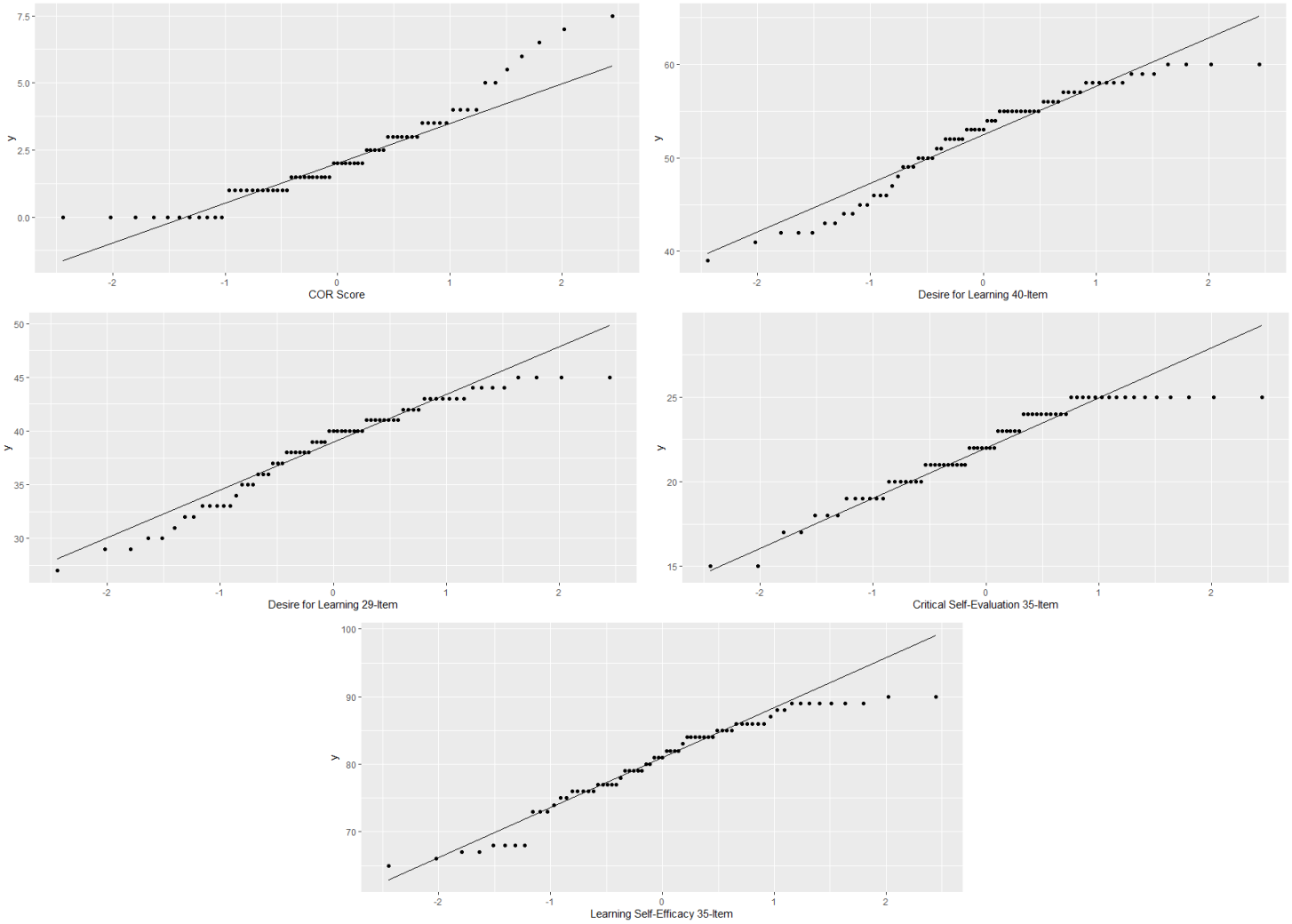


Figure 7

Q-Q Plots for Study Variables that Violated Normality Test



Data Transformations

Data transformations can make interpretation of the analysis more difficult. This is particularly important when a commonly used scale is potentially being transformed (Tabachnick & Fidell, 2007). An altered interpretation was not a concern within this data set as the scales being modified were not necessarily meaningful on their own. Data transformations can be used to emphasize differences between scores that are clustered together. Tukey's Ladder of Powers was used for each data transformation (Tukey, 1977). Tukey's Ladder of Powers was accomplished in this study using the rcompanion package in R. In this package, Tukey's Ladder of Powers is completed as the software uses progressively larger values for lambda to maximize the Shapiro-Wilks *W* test statistic (Mangiafico, 2022). Variables with a negative skew were reflected before the transformation. The results of the data transformations are shown in Table 9. COR scores showed substantial positive skew while both DFL variables, CSE, and LSE showed substantial negative skew.

After the transformation, COR score, DFL (40), DFL (29), and LSE no longer violated the normality assumption. CSE continued to violate the normality assumption, but other transformations did not improve the overall result. The transformed values were then used in the analysis of multivariate normality.

Table 10

Data Transformation Results for Study Variables

Variable	Original Shapiro-Wilk		Lamda	New Shapiro-Wilk		Skewness	Kurtosis
	Statistic	*P*		Statistic	*p*		
COR	0.912	<.001***	0.375	0.954	.013	0.078	-0.423
DFL (40)	0.936	.002**	0.450	0.973	.147	-0.035	-0.755
DFL (29)	0.941	.003**	0.450	0.977	.226	-0.014	-0.672
CSE	0.914	< .001***	0.625	0.926	< .001***	0.216	-0.972
LSE	0.940	.002**	0.500	0.969	.086	-0.046	-0.809

Note. Significance codes: *** $p < .001$. ** $p < .01$.

Multivariate Normality

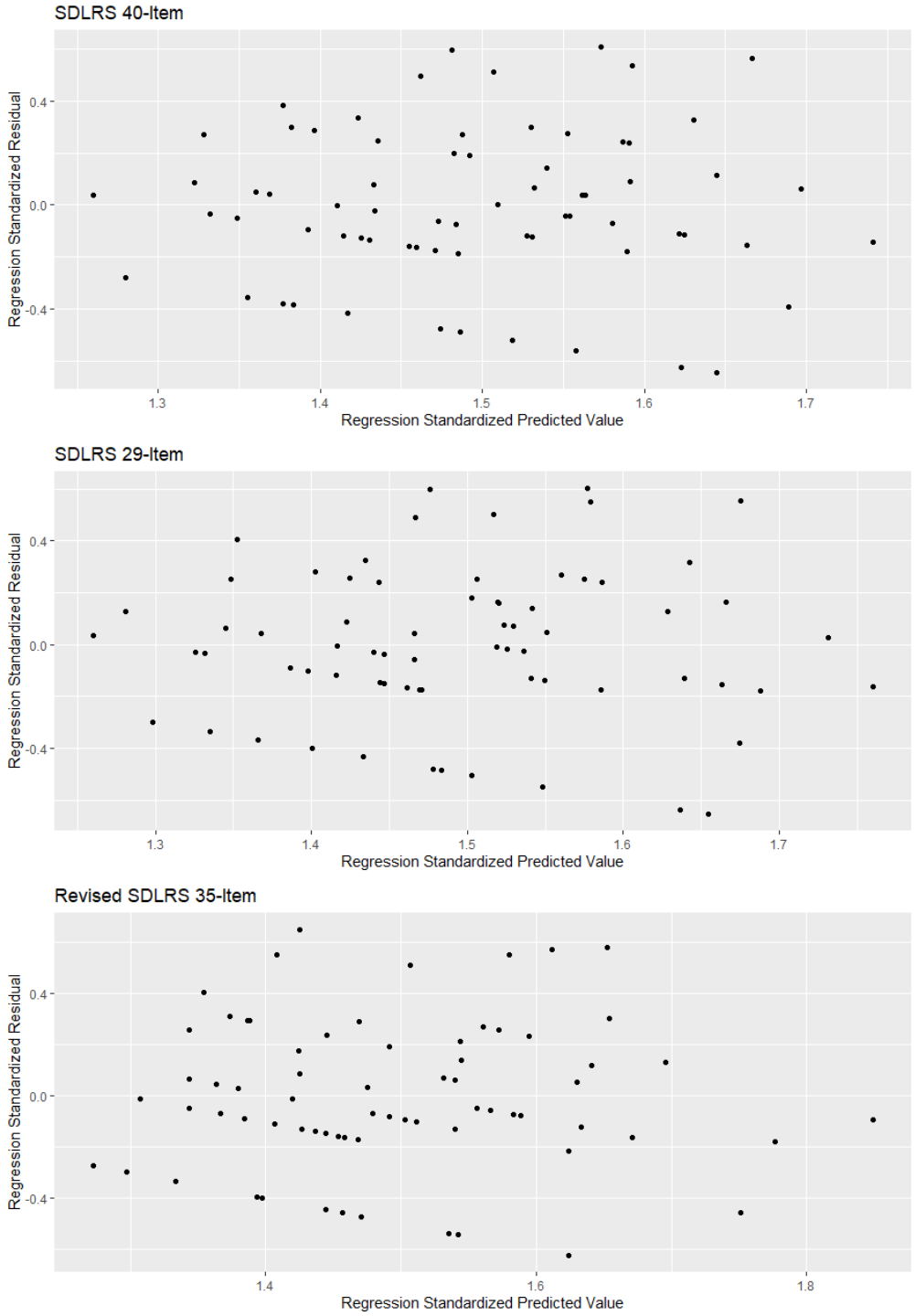
Multivariate normality was examined using Mardia's (1970, 1974) normalized estimate of multivariate kurtosis. Mardia's test was for the combinations of COR score, RRQ, and the subcomponents of the three SDLRS versions separately. The tests were run at the .05 significance level, and none showed violations of multivariate normality (Stevens, 2001). After these considerations, it was determined that the dataset did not have significant violations of univariate and multivariate normality, and the analysis was continued.

Linearity

Multivariate statistics assume that there is a linear relationship between variables. In this study, linearity was assessed primarily by examining residual plots. Residual plots were examined for COR score and each of the factors of the three SDLRS versions and RRQ. There were no indications of nonlinearity in any of the predictor variables. Three scatterplots were examined for the full model, one for each version of the SDLRS. The full model scatterplots are shown in Figure 8.

Figure 8

Scatterplot of the Standardized Residuals Plotted Against the Predicted Values For All Study Variables



Homoscedasticity

The assumption of homoscedasticity is that the dependent variable had consistent variability across the levels of independent variables (Meyers et al., 2017). This assumption was also tested using the scatterplots in Figure 8. Each scatterplot shows potential compression on the lower end of the plot. This compression indicates potential heteroscedasticity. One of the fixes for heteroscedasticity is data transformation, which had already been done (Meyers et al., 2017). This potential violation of the assumption of homoscedasticity was noted. Still, multivariate regression is a robust test with respect to some deviations from normality, so this was not expected to influence the results drastically.

Independence of Errors

There is also a statistical assumption that the error associated with the dependent variables is random and independent (Meyers et al., 2017). This assumption was tested by computing the *Durbin Watson* statistic (Durbin & Watson, 1971). The independence of errors was tested for the full model for each SDLRS version. For the 40-item SDLRS, the Durbin-Watson test statistic was 2.190 (p = .398), indicating independence of errors. For the 29-item SDLRS, the Durbin-Watson test statistic was 2.166 (p = .514), suggesting independence of errors. The 35-item Revised SDLRS had a Durbin-Watson test statistic of 2.089 (p = .710), also indicating independence of errors.

Multicollinearity

Multicollinearity was examined through the correlation matrix, shown in Tables 10, 11, and 12. None of the correlations exceeded .9, which would have indicated that those variables were highly correlated. The factors on each version of the SDLRS had the highest correlations with themselves. After the hierarchical linear regression was run for each model, the Variance

Inflation Factor (VIF) for each predictor variable was examined. DFL (40-item) had the highest VIF value (3.052), but this was below the acceptable threshold of 10 suggested by Marquardt (1970). The combination of the findings indicated no significant concerns about multicollinearity among the study variables.

Reliability

For the 40-item SDLRS, Cronbach's α for the total scale was .93, for self-management (13 items) Cronbach's α = .87, desire for learning (12 items) Cronbach's α = .84, self-control (15 items) Cronbach's α = .81. For the 29-item SDLRS, Cronbach's α for the total scale was .91, for self-management (13 items) Cronbach's α = .85, desire for learning (12 items) Cronbach's α = .79, self-control (15 items) Cronbach's α = .74. For the 35-item Revised-SDLRS, Cronbach's α for the total scale was .93, for critical self-evaluation (5 items) Cronbach's α = .78, effective organization for learning (8 items) Cronbach's α = .83, learning self-efficacy (18 items) Cronbach's α = .86, self-determination (4 items) Cronbach's α = .66.

Table 11

Correlation Matrix of Study Variables (40-Item SDLRS)

	1	2	3	4	5
1. COR Score[a]	--	--	--	--	--
2. DFL[b] (40-item)	0.061	--	--	--	--
3. SC (40-item)	-0.107	-0.746	--	--	--
4. SM (40-item)	-0.161	-0.689	0.723	--	--
5. RRQ	0.315	-0.125	-0.159	-0.164	--

Note. [a] Variable was transformed. [b] Variable was reflected and transformed.

Table 12

Correlation Matrix of Study Variables (35-Item Revised SDLRS)

	1	2	3	4	5	6
1. COR Score[a]	--	--	--	--	--	--
2. CSE[b](35-item)	0.102	--	--	--	--	--
3. EOL (35-item)	-0.204	--0.642	--	--	--	--
4. LSE[b] (35-item)	0.085	0.717	-0.633	--	--	--
5. SD	-0.16	-0.379	0.398	-0.449	--	--
6. RRQ	0.315	-0.284	-0.151	0.028	-0.257	--

Note. [a] Variable was transformed. [b] Variable was reflected and transformed.

Table 13

Correlation Matrix of Study Variables (29-Item SDLRS)

	1	2	3	4	5
1. COR Score[a]	--	--	--	--	--
2. DFL[b] (29-item)	0.0527	--	--	--	--
3. SC (29-item)	-0.076	-0.665	--	--	--
4. SM (29-item)	-0.189	-0.664	0.641	--	--
5. RRQ	0.315	-0.097	-0.148	-0.148	--

Note. [a] Variable was transformed. [b] Variable was reflected and transformed.

Research Question 1

Do the chosen COR tasks discriminate between different levels of reasoning ability in mid-career USAF and USSF officers and DAF civilians?

The first research question was answered using descriptive statistics. The sample included 95 participants who completed all three COR tasks with sufficient effort. The three COR tasks were chosen based on their previous use with undergraduate students. It was hypothesized that these tasks would provide a level of difficulty that would highlight different levels of reasoning ability among the population of total force USAF/USSF officers and DAF civilians. The Article Analysis and Social Media tasks had three potential scores: "*beginning*" (scored as 0), "*emerging*" (scored as 1), and "*mastery*" (scored as 2). The Researching a Claim task had a fourth score: "*partial mastery,*" which was scored as 1.5. Additionally, the Social Media task had two components that were scored separately. Table 14 shows participant performance on each task.

Table 14

COR Task Results

Assessment	Description	Participant Performance
Article Analysis	Explain the reliability of an article about the minimum wage.	59 (62.1%) Beginning 26 (27.4%) Emerging 10 (10.5%) Mastery
Social Media Part 1	Explain why a tweet may be a useful source of information about NRA members opinions.	81 (85.3%) Beginning 11 (11.6%) Emerging 3 (3.2%) Mastery
Social Media Part 2	Explain why a tweet may not be a useful source of information about NRA members opinions.	61 (64.2%) Beginning 27 (28.4%) Emerging 7 (7.4%) Mastery
Researching a Claim	Use the internet to evaluate the claim that Margaret Sanger supported euthanasia.	24 (25.3%) Beginning 24 (25.3%) Emerging 37 (38.9%) Partial Mastery 10 (10.5%) Mastery

Note. Errors due to rounding

Examination of the individual tasks showed that most participants showed a "*beginning*" level of COR for the Article Analysis and Social Media tasks. Relatively few of the students demonstrated "*mastery*" level performance. This indicates the tasks were not too easy, which would have created a ceiling effect. On the three tasks combined, participants could score between 0 and 8. The range of scores in this sample was 0 – 7.5. The mean score was 2.21, with a standard deviation of 1.77. Despite the high beginning scores on each task, only 15 participants had a cumulative score of 0. The majority of participants achieved at least the "*emerging*" level of performance on at least one task.

These results indicate that the chosen COR tasks differentiate between different reasoning ability levels in this sample. Overall, the participants struggled with COR, but different tasks seemingly targeted different aspects of reasoning ability. No participant achieved "*mastery*" on all tasks, and a minority of students only scored at the "*beginning*" level. This

differential level of ability is similar to the results by McGrew et al. (2019), indicating that they are appropriate for this population.

Research Question 2

Does the hypothesized model allow us to reliably predict performance on online reasoning tasks in mid-career USAF and USSF officers and DAF civilians?

Research Question 3

Which of the predictor variables are most influential in predicting performance on online reasoning tasks?

Research questions 2 and 3 were analyzed using hierarchical linear regression. All analyses were conducted in R. The SDLRS factors and RRQ were used as predictors, and COR score was the outcome variable. SDLR was entered first because it measures in part the motivation to engage in a learning project. RR was entered in the second step to determine its incremental contribution to the explained variance. Three separate hierarchical linear regressions were run to examine the three versions of the SDLRS. In each case, the SDLRS factors were added in step 1, and RRQ was added in step 2.

40-Item SDLRS

In model 1, DFL, SC, and SM were added as predictors, and COR score was the criterion. In model 2, RRQ was added as a predictor. The prediction equation in model 1 was not statistically significant ($F_{3,65} = 0.692$, $p = .560$). DFL, SC, and SM were not significant predictors of COR score. The regression equation accounted for approximately 3% of the variance in COR score ($R^2 = .031$, Adj. $R^2 = -.014$). The regression equation in model 2 was also not statistically significant ($F_{4,64} = 2.091$, $p = .093$). RRQ was a statistically significant predictor of COR score ($B = .008$, $\beta = .325$, $t = 2.474$, $p = .016$). DFL, SC, and SM were still not

significant predictors of COR score. With RRQ the regression equation accounted for approximately 11% of the variance in COR score (R^2 = .116, Adj. R^2 = .060). The change in R^2 was statistically significant ($F_{1,64}$ = 6.123, p = .016). See Table 13 for the full regression results.

29-Item SDLRS

In model 1, DFL, SC, and SM were added as predictors, and COR score was the criterion. In model 2, RRQ was added as a predictor. The prediction equation in model 1 was not statistically significant ($F_{3,65}$ = 1.039, p = .381). DFL, SC, and SM were not significant predictors of COR score. The regression equation accounted for approximately 5% of the variance in COR score (R^2 = .046, Adj. R^2 = .002). The regression equation in model 2 was also not statistically significant ($F_{4,64}$ = 2.317, p = .067). RRQ was a statistically significant predictor of COR score (B = .007, β = .304, t = 2.432, p = .018). DFL, SC, and SM were still not significant predictors of COR score. With RRQ the regression equation accounted for approximately 13% of the variance in COR score (R^2 = .127, Adj. R^2 = .071). The change in R^2 was statistically significant ($F_{1,64}$ = 5.916, p = .018). See Table 14 for the full regression results.

35-Item Revised SDLRS

In model 1, CSE, EOL, LSE, and SD were added as predictors, and COR score was the criterion. In model 2, RRQ was added as a predictor. The prediction equation in model 1 was not statistically significant ($F_{4,64}$ = 0.806, p = .528). DFL, SC, and SM were not significant predictors of COR score. The regression equation accounted for approximately 5% of the variance in COR score (R^2 = .048, Adj. R^2 = -.011). The regression equation in model 2 was also not statistically significant ($F_{5,64}$ = 2.127, p = .074). RRQ was a statistically significant predictor of COR score (B = .008, β = .330, t = 2.665, p = .009). DFL, SC, and SM were still not significant predictors of COR score. With RRQ the regression equation accounted for

approximately 14% of the variance in COR score (R^2 = .144, Adj. R^2 = .077). The change in R^2 was statistically significant ($F_{1,63}$ = 7.101, p = .010). See Table 15 for the full regression results.

RRQ as the Sole Predictor

SDLR was not significant in any of the tested models. However, RRQ remained a significant predictor of COR score. A simple linear regression was conducted with RRQ as the sole predictor of COR score. The prediction equation was statistically significant ($F_{1,67}$ = 7.375, p = .008). RRQ explained about 10% of the variance in COR scores (R^2 = .099, adj. R^2 =.086). RRQ was a significant predictor of COR score (B = .008, β = .315, t = 2.716, p = .008). An increase in RRQ predicted an increase in COR score.

In summary, none of the models that included versions of the SDLRS reliably predicted COR score. None of the factors of SDLRS were significant predictors. When RRQ was added to the models, it was a significant predictor, so it was analyzed as the sole predictor through simple linear regression. RRQ was a moderate predictor of COR score within this sample.

Table 15

Hierarchical Regression for COR Ability (SDLRS 40-Item)

Variable	*B*	95% CI for *B*		*SE B*	β	R^2	ΔR^2
		LL	*UL*				
Step 1						.031	.031
Constant	2.187	0.463	3.910	0.863			
DFL 40-Item	-0.045	-0.201	0.111	0.078	-.112		
SC 40-Item	-0.008	-0.023	0.007	0.007	-.210		
SM 40-Item	-0.002	-0.026	0.022	0.012	-.039		
Step 2						.116	.085*
Constant	0.405	-1.791	2.602	1.099			
DFL 40-Item	0.040	-0.125	0.205	0.083	.099		
SC 40-Item	-0.004	-0.019	0.010	0.007	-.110		
SM 40-Item	0.006	-0.018	0.029	0.012	.099		
RRQ	0.008	0.002	0.015	0.003	.325*		

Note. Significance codes: *** $p < .001$. ** $p < .01$. * $p < .05$

Table 16

Hierarchical Regression for COR Ability (SDLRS 29-Item)

Variable	*B*	95% CI for *B*		*SE B*	β	R^2	ΔR^2
		LL	*UL*				
Step 1						.046	.046
Constant	2.038	0.550	3.525	0.745			
DFL 29-Item	-0.053	-0.215	0.108	0.081	-.118		
SC 29-Item	-0.015	-0.033	0.003	0.009	-.286		
SM 29-Item	0.002	-0.027	0.032	0.014	.029		
Step 2						.126	.081*
Constant	0.635	-1.206	2.475	0.921			
DFL 29-Item	0.011	-0.153	0.176	0.082	.025		
SC 29-Item	-0.010	-0.028	0.007	0.009	-.201		
SM 29-Item	0.010	-0.019	0.038	0.014	.114		
RRQ	0.008	0.003	0.014	0.003	.304*		

Note. Significance codes: *** $p < .001$. ** $p < .01$. * $p < .05$

Table 17

Hierarchical Regression for COR Ability (Revised SDLRS 35-Item)

Variable	*B*	95% CI for *B*		*SE B*	β	R^2	ΔR^2
		LL	*UL*				
Step 1						.048	.048
Constant	1.858	0.842	2.874	0.509			
CSE	-0.003	-0.122	0.115	0.060	-.011		
EOL	-0.015	-0.034	0.004	0.010	-.266		
LSE	-0.014	-0.124	0.097	0.055	-.046		
SD	0.008	-0.029	0.046	0.019	.064		
Step 2						.144	.096**
Constant	0.588	-0.772	1.948	0.681			
CSE	0.020	-0.095	0.135	0.058	.064		
EOL	-0.011	-0.029	0.008	0.009	-.187		
LSE	-0.005	-0.110	0.101	0.053	-.016		
SD	0.022	-0.016	0.059	0.019	.160		
RRQ	0.008	0.002	0.015	0.003	.330**		

Note. Significance codes: *** $p < .001$. ** $p < .01$. * $p < .05$

Research Question 4

Do promotion category and level of education predict RR ability among mid-career USAF and USSF officers and DAF civilians?

Research Question 5

Do promotion category and level of education predict SDLR among mid-career USAF and USSF officers and DAF civilians?

MANOVAs were used to determine if promotion category and the highest level of education predicted SDLR or RRQ. If differences were found through the MANOVA analyses, post hoc tests would be used to identify which groups had statistically significant differences. A separate MANOVA for each version of the SDLRS and RRQ for the promotion category and the highest level of education.

Promotion Category

Three MANOVAs were used to determine if the promotion category predicted SDLR and RRQ. For the 40-item version of the SDLRS and RRQ, no statistically significant differences were found based on promotion category, Pillai's Trace = .646, F (48, 224) = 0.900, p = .661. For the 29-item version of the SDLRS and RRQ, no statistically significant differences were found based on promotion category, Pillai's Trace = .683, F (48, 224) = 0.961, p = .551. For the 35-item version of the SDLRS and RRQ, no statistically significant differences were found based on promotion category, Pillai's Trace = .812, F (60, 280) = 0.905, p = .672. Due to the non-significant results, no post hoc tests were conducted. Because of the small sample size, an additional set of MANOVAs was run with fewer promotion categories. The Chaplain and Judge Advocate General promotion categories were included with OTHER because each category only had one participant. All of the medical career fields were combined into a MEDICAL category.

The overall number of promotion groups was reduced from 13 to 8. The new analyses still did not find statistically significant differences between promotion categories for SDLRS or RRQ.

Highest Level of Education

Three MANOVAs were used to determine if the highest level of education predicted SDLR and RRQ. For the 40-item version of the SDLRS and RRQ, no statistically significant differences were found based on level of education, Pillai's Trace = .221, F (16, 256) = 0.783, p = .529. For the 29-item version of the SDLRS and RRQ, no statistically significant differences were found based on promotion category, Pillai's Trace = .270, F (16, 256) = 1.158, p = .302. For the 35-item version of the SDLRS and RRQ, no statistically significant differences were found based on promotion category, Pillai's Trace = .248, F (20, 252) = 0.834, p = .971. The results of each MANOVA showed no statistically significant differences between groups based on the highest level of education. Due to the non-significant results, no post hoc tests were conducted.

Summary

This chapter presented the results of the statistical analysis plan outlined in Chapter 3. The chapter opened with an analysis of the assumptions of multivariate statistics, including normality, linearity, homoscedasticity, and independence of errors. The data was also screened for plausibility, outliers, and multicollinearity. The chapter then presented analyses related to the five research questions posed by this study.

Descriptive statistics were used to assess the acceptability of using these COR tasks with a population of mid-career USAF and USSF officers and DAF civilians. Participants in this study showed varying degrees of COR ability. Most participants demonstrated "*emerging*" reasoning performance on at least one of the tasks. No student achieved "*mastery*" on all three

tasks, and a minority of participants scored "*beginning*" on all tasks. These tasks were effective at differentiating participants based on their COR performance.

Hierarchical linear regression was used to evaluate the full model. Each of the three versions of the SDLRS was used separately as predictors along with RRQ. In each case, the factors of the SDLRS were not statistically significant predictors of COR ability. RRQ was a statistically significant predictor when it was used in each of the three models. It was also statistically significant when entered as the sole predictor of COR ability. Based on this analysis, RRQ seems important in understanding how adults process information online.

MANOVAs were used to identify factors that may influence SDLR and RRQ within this population. Promotion category and the highest level of education were identified as potential influences on the development of these skills and dispositions. Neither promotion category nor the level of education were statistically significant predictors of SDLR or RRQ.

Chapter 5: Summary, Discussion, and Conclusions

This chapter serves as the culmination of the current study. It includes a summary of the study and then addresses key findings and considerations for interpreting the findings. The chapter concludes with a discussion of implications for practice and addresses aspects of the study that need further research.

Summary

The challenge of navigating information online in a saturated media environment filled with falsehoods has been well-documented (e.g., Breakstone et al., 2019; Horn & Veermans, 2019; Marttunnen et al., 2021; Nygren & Guath, 2019). Researchers have found that people from all sections of society struggle to evaluate the information they encounter online. This struggle has both societal and personal implications. These struggles persist despite a prolonged emphasis on critical thinking at all levels of education. This study investigated the extent of COR skills, SDLR, and RR ability in the population of mid-career USAF and USSF officers and DAF civilians. The study also tested a model for predicting online reasoning skills based on the two-factor theory of CT.

The purpose of this non-experimental, quantitative, correlational study was to explore the relative influence of relational reasoning ability and self-directed learning readiness on online reasoning ability in mid-career Total Force USAF/USSF members enrolled in the in-residence and asynchronous offerings of a professional military education course. The hypothesized model was based on prior research and the existing literature.

Kavanagh and Rich (2018) argue that the current information environment is characterized by four trends that lead to a phenomenon they call Truth Decay. The first trend is growing disagreement about data and reasoned analysis of facts and information. The second

trend is that, much like the yellow journalism era, fact and opinion are being integrated in ways that make them hard to distinguish. Third, personal experience and opinions are becoming more important and powerful in discourse about presumably factual issues. The fourth trend is that people are losing their trust in formerly reputable distributors of information. Barzilla and Chinn (2020) similarly described the current information environment but added that news consumption is becoming increasingly fragmented and that misinformation and disinformation are increasingly prevalent. The internet and social media exacerbate the problem of truth decay by furthering the Truth Decay trends. The lack of clarity on what and who to believe can lead to degraded trust overall, which can have society-wide implications.

Critical thinking has been proposed as a mechanism for battling misinformation at the individual point of exposure (Axelson et al., 2021; Barzilai & Chinn, 2020; Horn & Veermans, 2019; Zucker, 2019). Critical thinking has been conceptualized as more than just a cognitive skill. The two-factor theory proposes that critical thinking skills are affected by cognitive abilities and personality dispositions (Clifford et al., 2004). Within this conceptual framework, this study looked at the relationship between COR, RR, and SDLR.

COR is a concept that can be used to evaluate critical thinking in an environment characterized by Truth Decay. COR served as the dependent variable in this study. SDLR and RR were examined as predictors of COR ability. They were hypothesized to be concepts that would account for some skills and dispositions critical thinkers need. SDLR provides a framework for exploring individual differences in peoples' inclination to engage in SDL and their capacity to carry out a learning project. Learners who can plan and evaluate their learning while exhibiting self-control may better navigate the complexities of online information. Under the two-factor theory of critical thinking, RR represents vital cognitive abilities that allow

individuals to make reasoned judgments about the world around them. To think critically, a person must be able to analyze and evaluate information and situations. That requires the ability to see patterns and differences between other situations and information encountered in the past. Understanding differences between current and previous events allows people to respond flexibly to new opportunities and threats. Cognitive abilities like RR are necessary to complement a person's desire to learn new things and think deeply about the world around them.

The study was conducted using a non-experimental quantitative research design using an anonymous, online instrument. This research design was chosen because there was no way to control for or alter the independent variables in the model. The purpose of the research was to understand how well the dependent variables predict the independent variable when measured contemporaneously. COR was measured with tasks designed by McGrew et al. (2018). Participants completed three tasks that had previously been studied with undergraduate students. Participants also completed the 40-item SDLRS created by Fisher et al. (2001). Two other variants of the SDLRS were also examined that used a subset of items from the full version. The 35-item revised SDLRS (Hendry & Ginns, 2009) and a 29-item version by Fisher & King (2010) were examined independently. Participants also completed the 32-item TORR (Alexander et al., 2016).

The following research questions were considered:

Research Question 1: Do the chosen COR tasks discriminate between different levels of reasoning ability in mid-career USAF and USSF officers and DAF civilians?

Research Question 2: Does the hypothesized model allow us to reliably predict performance on online reasoning tasks in mid-career USAF and USSF officers and DAF civilians?

Research Question 3: Which of the predictor variables are most influential in predicting performance on online reasoning tasks?

Research Question 4: Do promotion category and level of education predict RR ability among mid-career USAF and USSF officers and DAF civilians?

Research Question 5: Do promotion category and level of education predict SDLR?

The accessible population for this study was mid-career officers and DAF civilians in two versions of a PME course. Participants were recruited from three iterations of the in-residence course between December 2021 and April 2022 (1,776 students). All 3,237 students enrolled in the asynchronous course as of March 22, 2022, were invited to participate. In total, 251 eligible participants registered a response in Qualtrics for a total response rate of 5.0%.

A total of 101 participants (101/251, 40.2%) completed all 3 COR tasks. Analysis of the COR task responses revealed six participants whose responses were insufficient to score fairly. The final sample for COR task analysis included 95 participants (37.8%) who successfully completed all three tasks with sufficient effort. Out of the 101 participants who completed the COR tasks, 80 (80/251, 31.9%) completed the entire survey. Five participants who completed the entire survey were from the group of low-effort participants, and they were removed from further analysis. There were 6 participants who failed both of the instructed response questions either by answering incorrectly or not answering those items. Further analysis determined that none of these participants were univariate or multivariate outliers or otherwise notable cases, and they were removed from the data set. The final sample for analysis of research questions 2-5 was 69 (27.5.%).

The final sample approximates the race/ethnicity of the USAF and USSF. However, because the sample is so small, the number of participants in racial and ethnic minority groups is

minimal. The final sample contains a much larger percentage of women than the USAF and USSF. This sample should not be considered representative of the USAF and USSF or the population of mid-career officers and DAF civilians.

Key Findings

Descriptive statistics, MANOVA, and hierarchical linear regression were used to answer the research questions. Descriptive statistics were used to answer RQ1. The theory-based model underpinning RQs 2 and 3 was evaluated using hierarchical linear regression. Differences in SDLRS score and RRQ based on level of education and promotion category were examined using MANOVAs as outlined in RQs 4 and 5. The evidence from these analyses supports the following findings within the sample of mid-career Total Force PME students.

1. The COR tasks showed differential levels of reasoning among the participants.
2. Participants struggled with analyzing online information
3. RRQ predicted COR
4. The participants showed similar levels of RR ability to other populations
5. The three versions of the SDLRS did not reliably predict COR ability in this population

Different levels of COR ability

The Stanford History Education Group (SHEG) has developed a variety of COR tasks and curriculum items for students of varying ability levels (SHEG). This study sought to find appropriate tasks for a working professional population. The three chosen tasks had previously been used with 141 undergraduate students from universities on the East and West Coasts. The tasks had proved difficult for undergraduate students, and it was hypothesized that while the sample in this study may perform better, the tasks would still differentiate different degrees of

reasoning ability. Table 17 compares the results of McGrew et al. (2018) and the sample from this study. For two of the three tasks, the participants in this study provided fewer "*beginning*" and more "*mastery*" levels responses. On the Social Media task, the participants in McGrew et al.'s (2018) study demonstrated a higher level of COR ability. This study showed that these tasks provide a sufficient challenge to a working professional population and may be useful as a test of reasoning ability.

Table 18

COR Task Results

Assessment	Description	This study	Previous research[a]
Article Analysis	Explain the reliability of an article about the minimum wage.	59 (62.1%) Beginning 26 (27.4%) Emerging 10 (10.5%) Mastery	80% Beginning[b] 12% Emerging[b] 8% Mastery[b]
Social Media Part 1	Explain why a tweet may be a useful source of information about NRA members opinions.	81 (85.3%) Beginning 11 (11.6%) Emerging 3 (3.2%) Mastery	59% Beginning 35% Emerging 7% Mastery
Social Media Part 2	Explain why a tweet may not be a useful source of information about NRA members opinions.	61 (64.2%) Beginning 27 (28.4%) Emerging 7 (7.4%) Mastery	49% Beginning 30% Emerging 7% Mastery
Researching a Claim	Use the internet to evaluate the claim that Margaret Sanger supported euthanasia.	24 (25.3%) Beginning 24 (25.3%) Emerging 37 (38.9%) Partial Mastery 10 (10.5%) Mastery	62% Beginning 24% Emerging 9% Partial Mastery 5% Mastery

Note. Errors due to rounding. [a] McGrew et al., (2018). [b] Combined results for high school and college students.

Challenge of analyzing online information

Building upon the previous finding, this study also showed that this sample of mid-career USAF and USSF officers and DAF civilians struggle to evaluate online information. This study highlights the challenge of evaluating online information and validates previous research by Breakstone et al. (2019), Horn and Veermans (2019), Marttunnen et al. (2021), McGrew et al. (2018), and Nygren and Guath (2019) who used similar tasks on students from middle school through college. In their initial study on COR, McGrew et al. (2018) found that participants were prone to judge the information solely based on the content or to focus on superficial details. Participants also failed to dig into the source of information or were satisfied by surface-level research. Many of these trends were also noted in this study.

Article Evaluation

On this task, only ten students demonstrated "*mastery*" level performance which required students to realize the article was unreliable and that the website was funded by a lobbying firm for the food and beverage industry. The task rubric is included in Appendix A.

Several students researched who funded the website and examined how the motivations and agenda of that group may have influenced the article's content. Participant 36 wrote: "The website is run by EPI, which has had ties to political movements in the past... I went to the 'About Us' tab on the website, and found that it was run by EPI. I then quickly researched EPI to see what kind of bias the organization might have and any agendas they might push. The article linked was directly tied to these perspectives." Other participants followed a similar line of reasoning. Additional students noted that the article made claims beyond the reasonable scope of the information presented. Participant 165 noted, "[The article] only examines one country's and one restaurant dealing with paying workers (sic) higher minimum wage. There is no large study

done. The study needs to involve more than one location, more than one business. There is also no timeline to see long term affects (sic) of raising minimum wage." In both cases, the students presented responses that carefully examined areas of concern with the article and its overall credibility.

Other students showed some of the same issues found by previous researchers. Some participants believed the article was credible. Participant 227 deemed the article credible because it cited sources. Another participant, number 66, considered the website somewhat credible because it was run by a non-profit. That participant correctly identified the Employment Policy Institute as a parent organization but failed to investigate the motivations of that organization further. The parent organization's non-profit status swayed several other students. Participant 34 discounted the website's credibility because "[i]t's a .com--not a .org or .gov or something of that sort." Neither of those explanations addressed the main areas of concern.

Social Media

Participants in this study had the lowest scores on the two parts of the social media task. Part one of this task required students to explain why a tweet from MoveOn.org might be a useful source of information about NRA members' opinions on background checks. The tweet cited a poll sponsored by another liberal organization and conducted by a reputable polling firm. Only three students demonstrated mastery performance on this part of the task. The second part prompted students to explain why the tweet may not be a useful source of information, and seven students showed "*mastery*" performance. In part 1, participants needed to recognize that a reputable polling agency conducted the poll. For part 2, participants needed to address the political motivations of the organization presenting the information. The task rubric is included in Appendix A.

On part 1 of this task, participant 66 wrote that "The poll was organized by the Public Policy Polling, which according to Wikipedia has performed accurate polls in the past. Polls are not perfect but they can certainly give an insight -- in this case amongst the NRA. The poll might be slightly skewed due to the fact that the PPP is a Democratic organization and the target audience for the poll is NRA members who are not traditionally democrat." Participant 127 looked deeper into who was included in the poll's sample and researched the polling company: "The survey did include approximately 195 individuals who self-identified as being a member of the NRA. Additionally, website FiveThirtyEight gives Public Policy Polling (PPP) a grade of A-based (sic) on analysis of 454 surveys conducted by the group." These participants proved to be in the minority. Many more students failed to articulate reasons why the tweet may be helpful, and numerous participants failed to recognize that the poll came from a reputable source.

Participant 110 noted the tweet's source but found it useful because it was from a verified Twitter account. Other participants argued that Twitter should not be a source of information (e.g., participant 51). Some participants found the tweet potentially useful because the organization tweeting it was a non-profit (e.g., participants 176, 162). Other participants focused on the professional-looking graphics (participant 7). Some participants found the tweet useful because it provided information in contrast to what they perceived as the prevailing opinion. For example, participant 205 wrote, "It could be a useful source because most people would probably think that NRA members would NOT support background checks because it would seem to be a hindrance to obtaining a firearm." That participant failed to assess the source of that information and whether the tweet's assertion was correct.

Researching a Claim

In this task, only ten students demonstrated "*mastery*" level performance, while another 37 achieved the "*partial mastery*" level. This task required participants to search the internet to evaluate the claim that Margaret Sanger supported euthanasia. "*Mastery*" level performance required students to demonstrate clear reasoning and evaluate the reliability of their sources. The task rubric is included in Appendix A.

Participants who demonstrated "*mastery*" performance made a reasoned argument about Sanger's beliefs based on sources that they determined to be credible. Participant 238 wrote, "This claim likely stemmed from Margaret Sanger's support of the Eugenics movement, not euthanasia. She supported the limitation of procreation on a number of levels, but specifically spoke out against euthanasia." That participant used quotes from Sanger to further back up their analysis and then used multiple sources they deemed credible in their argument. Participant 75 used Wikipedia as a starting point to find other credible sources. They also used information from the New York Times, Time Magazine, and a book that included quotes from Sanger.

Students who only achieved "*partial mastery*" provided a reasoned analysis but did not include an evaluation of their sources. The sources may have been credible, but the participant did not explain why they believed that to be the case. Participant 142 simply listed their sources, including https://www.womenshistory.org/education-resources/biographies/margaret-sanger, https://www.britannica.com/biography/Margaret-Sanger, https://www.merriam-webster.com/dictionary/eugenic, https://www.merriam-webster.com/dictionary/euthanasia. Many students used the same sources, indicating that they were likely near the top of the first page of search results.

Other students failed to find enough credible evidence to address the claim. Participant 101 wrote that "I am still unsure if Sanger supported euthanasia. The sources I found harped on

Sanger's support for eugenics and there were other sources that state that the link between eugenics and euthanasia stem from the same ideals, however, it is not enough for me to state one way or the other specifically about Sanger." In a similar sentiment, participant 129 wrote, "I do believe this, but I could not find any websites stating this fact or any direct quotes from her." Other participants noted the problematic nature of sifting through partisan information sources "The sources were all very polarized and I don't think any of them were particularly strong." These participants highlighted the difficulty in finding credible information within a short time frame, particularly on a topic the participant may not be familiar with.

The final subset of participants demonstrated the lowest level of performance. Participant 23 wrote, "Yes, because she was known to be an avid racist." That participant did not cite any sources to back up their assertion. Participant 85 argued that "It doesn't matter if she supported euthanasia. Planned Parenthood is about supporting women's (and everyone's) rights' to do what they need/want with their bodies. The foundational principles of planned parenthood and the founder's personal opinions don't really matter except for when people want to use it as a political weapon." Both of these participants' answers indicate that other issues and prior beliefs may have influenced their motivation to engage at a deeper level with the prompt. Some participants provided minimal analysis with a shallow evaluation of their sources, "She could have. She was a supporter of people doing what they want with their body. I did use the Supreme Court website for some of the research."

Participants Struggled with Analyzing Online Information

This study highlighted differences in reasoning ability within a sample of USAF and USSF officers and DAF civilians. A minority of participants reached the "*mastery*" performance level. Given the short time frame allowed by the tasks, many students provided shallow or

incomplete arguments or were misled by surface-level aspects of the information sources. The results of this research are in line with other research studies using online reasoning tasks. Using similar tasks Horn and Veermans (2019), Martunen et al. (2021), McGrew et al. (2018), and Nygren and Guath (2019) found that participants from middle school through undergraduate students struggled to evaluate online information. This study extended those results to a population of working professionals with varying levels of education beyond undergraduate work. These findings are consistent with other studies showing that adults struggle with evaluation information in a variety of formats (e.g., Kahne. & Bowyer, 2017; Lewandowsky et al., 2017; Rich & Zaragoza, 2016; Sangalong et al., 2019; Sindermann et al., 2021; Spezano & Winiecki, 2020).

The purpose of the COR tasks in this study was to determine if the tasks were useful to differentiate reasoning ability in this population and to measure online reasoning ability. The written responses provide some indications of areas that may warrant further study. Kahne and Bowyer (2017) found that political motivations influence how people approach information they encounter. The COR tasks were not intended to address motivated reasoning directly, but some participants seemed to be influenced by their prior beliefs. Participant 22 wrote that the tweet in the Social Media task was not trustworthy "Because Twitter is inherently biased towards a liberal agenda. The words are phrased in such a way that its saying that the NRA isn't about responsibility whereas the reality it(sic) gun owners are about responsibility. Obviously criminals shouldn't have guns." This response indicates that the participant had strong feelings on the issue of gun control. McGrew et al. (2018) found that some participants in their sample focused on superficial markers of perceived credibility. The same trends were found in some participants in this study. A few participants gave undue deference to the non-profit status of the

organization responsible for the article on minimum wage. When presented with a tweet that was based on a poll from a reliable firm, several participants focused on the appearance of the tweet or analysis of the hashtags and graphics. Finally, there was evidence that Truth Decay impacted a few participants. These participants wrote that they did not know who to trust or were not sure that any sources were credible. Participants also expressed varying degrees of trust in traditional news organizations. These feelings are potentially exacerbated by declining trust in traditional media overall or the fragmentation and polarization of news consumption.

This study also added to the research by Stone (2017). Stone found that officers in higher levels of PME were not necessarily better at critical thinking than their civilian equivalents and that those skills may not have improved over time. More research is needed to develop these findings further, but this study found similar results with a younger population of Total Force personnel. Despite an explicit emphasis on critical thinking skills, more work must be done.

Relationship between RRQ and COR

This study found RRQ to be a statistically significant predictor of COR ability. It was hypothesized that the ability to find patterns and non-patterns would relate to parsing information from various sources online as required by the COR tasks. This hypothesis had a theoretical foundation in the conceptualizations of critical thinking skills and dispositions described earlier. Hierarchical linear regression was used to analyze the relative influence of SDLR and RRQ on COR ability. RRQ was added as the second step in each hierarchical linear regression analysis to determine its predictive power beyond SDLRS alone. In each case, RRQ was a statistically significant predictor. A regression was also run with RRQ as the sole predictor. In this case, the prediction equation was statistically significant ($F_{1, 67} = 7.375$, $p = .008$). RRQ explained about 10% of the variance in COR scores ($R^2 = .099$, adj. $R^2 = .086$). RRQ was a significant predictor

of COR score (B = -.008, β = .315, t = 2.716, p < .008). Participants with a higher score on the RRQ were more likely to score higher on the COR tasks. These findings align with Fountain (2016), who found a relationship between RRQ and CT in the context of nursing.

Level of RRQ compared to other populations

RR ability in this sample was comparable to other populations of undergraduate students and working adults. In designing the TORR, Dumas and Alexander. (2016) calibrated RRQ to have a mean of 100 in their population of undergraduate students. In this study, the mean RRQ was 100.59, with a standard deviation of 12.41. Fountain's (2016) sample consisted of nurses from the prelicensure stage to nurses having more than ten years of experience. Nurses who were licensed with less than ten years of experience had a mean RRQ of 95.22, while nurses with more than ten years of experience had a mean RRQ of 99.50. The sample in this study was similar to the population of undergraduate students and nurses with varying levels of working experience.

Relationship between SDLR and COR ability

The results of this study did not support the hypothesis that SDLR would predict COR ability. Three versions of the SDLRS that had been previously validated were examined. During Fisher et al.'s (2001) development of the SDLRS (40-item), the mean total score was 150.55 (S.D. 18.34). The participants in this study had a mean of 168.71 on the 40-item original SDLRS. Other studies found higher mean scores for SDLRS using the 40-item scale. Phillips et al. (2015) had a mean of 160 in their sample of non-traditional nursing students. Williams et al. (2013) found means closer to 160 across different groups of undergraduate paramedic students in Australia. The 29-item (Fisher & King, 2010) and 35-item versions (Hendry and Ginns, 2009)

had similar proportionately high means, 117.49 out of 140 possible and 148.68 out of 175 possible.

Three hierarchical linear regressions were used to analyze the SDLRS versions separately. The factors of each version were entered in step 1 or each regression. It was hypothesized that SDLRS would represent aspects of the disposition to engage in online reasoning. All three regression equations were not statistically significant, and none of the factors for any SDLRS versions significantly predicted COR ability. It is unclear from this study if this instrument accurately measured SDLR in this sample. It is possible that the circumstances of this study or the characteristics of this sample influenced how the participants responded. Future research would need to explore other possible ways to measure SDLR in this population.

Considerations

Several issues should be considered when examining the results of this survey. The participants were asked to take approximately 60 minutes to complete the survey. The flow of the survey was designed to progressively decrease the cognitive burden required by the participant. Participants who demonstrated inattentiveness or lack of effort were removed from the final sample, but it is still possible that the survey length influenced how much consideration the participants gave to individual questions.

The length of the survey also led likely led to a highly self-selecting sample. The survey had a low overall response rate, and only 29.9% of the participants who recorded a response were retained in the final dataset for RQs 2-5. It is likely that the students who opted not to participate differ substantially from those who completed the survey. Additionally, the sample was not representative of the overall demographics of the classes or the USAF and USSF officers corps.

Research on COR needs to balance the need to use tasks that have been used with other populations while also developing and evaluating new tasks. A minority of participants in this study made note of the datedness of the information. One participant found reference to the article analysis task being used in other research, which influenced their response.

Implications

The two-factor theory of CT provides a useful framework for examining the implications of this study. CT is a stated goal of USAF PME, and minimal research has been done to explore the state of these skills within the servicemember population. COR ability was used as the dependent variable and as one aspect of critical thinking. The results of this study suggest that many mid-career USAF and USSF officers and DAF civilians struggle to analyze the information they encounter online. PME should invest in deliberately assessing and building CT skills within various contexts to ensure that service members are equipped with the cognitive tools to accomplish their missions. This requires finding additional ways to measure critical thinking and interventions to build skills.

CT dispositions encompass the factors that lead a person to engage in CT. This study hypothesized that SDLR would encompass some dispositional components that would lead the participants to engage in deeper thinking. SDLR was not a significant predictor of COR ability in this sample. Finding appropriate measures of CT dispositions should be a priority for researchers in this field. CT skills are not enough if people do not choose to use them.

On the skills dimension, this study showed that RR might be a fruitful avenue for continued study of CT. RR represents foundational cognitive abilities that have many potential applications. In this study, RR was a small but significant predictor of COR ability. This study also indicated that RR ability in this population was similar to the abilities of undergraduate

students. The Air Force should look into methods for improving RR in the Total Force population. RR may also impact other areas of interest to USAF and USSF personnel. There is also a need to find other measures of CT skills that can predict online reasoning ability.

Future Directions

CT continues to be an area that warrants further research. Both this study and research by Stone (2017) have indicated that the military officer population is not immune to the challenges of CT. The two-factor theory of CT provides a useful framework for identifying skills and dispositions that influence how people reason both generally and in specific contexts. This study used three tasks where participants demonstrated varying degrees of reasoning ability. Future research should include more tasks and other measures of online reasoning to provide a fuller picture of CT skills within the USAF and USSF. Additionally, limited research has been conducted on the enlisted population or with cadets and officer candidates. It is also important to extend the CT study to these populations.

Longitudinal research would also provide evidence for how well these competencies are being developed across the length of a career. Stone (2017) conducted a cross-sectional study, but most officers were still left out of his design. Intentional effort should be focused on how PME, occupation-focused educational opportunities, and different career experiences build reasoning skills.

The two-factor theory of CT theorizes that CT requires both skills and dispositions. RR only accounts for one aspect of cognitive skills. Concerning online reasoning, more dispositional components of reasoning need to be investigated. This study highlighted some areas meriting further investigation within this population. A mixed methods study would provide deeper insight into other factors influencing how adults process online information. This

type of research may also provide additional insight into the true state of SDLR within this population. The modern world requires adults to learn and refresh their skills continually. SDLR provides a potential avenue not just for online reasoning but also for ensuring that military members stay relevant across their careers. A better understanding of SDLR in this population or identifying other dispositional concepts would allow the USAF and USSF to continue refining their educational practice.

Finally, combining theoretical research with interventions to improve educational practice is important. CT is an essential outcome of higher education, and the goal should be to enhance educational practice to help people reason well. Research into interventions should also consider their long-term efficacy. The USAF and USSF education structure provide an opportunity because they are usually relatively short, and the students may participate more as working professionals than as full-time students. This dynamic may lead to different results than would be found on a university campus and would be more relevant to this population.

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Appendix A

COR Task Rubrics

Article Evaluation Rubric

This assessment asks students to determine whether this article on MinimumWage.com is a reliable source of information. Successful students will discover that, despite its non-partisan description, links to research reports and news articles, and professional appearance, MinimumWage.com is in fact managed by lobbyists for the food and beverage industry. MinimumWage.com's parent organization, the Employment Policies Institute, is a front group for Berman and Company, a Washington, D.C.-based lobbying firm. According to the *New York Times*, the firm's owner, Richard Berman, has a track record of creating "official-sounding nonprofit groups" to disseminate information on behalf of corporate clients.

Mastery	Student rejects the website as a reliable source and provides a clear rationale based on a thorough evaluation of the organizations behind MinimumWage.com.
Emerging	Student rejects the website as a reliable source and identifies the intent of the website's sponsors but does not provide a complete rationale.
Beginning	Student accepts the source as trustworthy or rejects the source based on irrelevant considerations.

Sample Responses

Mastery

In an open web search, this student researches the organization behind MinimumWage.com and the Employment Policies Institute, describes a lobbyist's role in the organizations, and rejects the source based on this information.

This website seems rather biased in terms of the information it presents regarding raising the minimum wage. I think it might make sense to cite this source as representative of the arguments made by opponents of raising the minimum wage, but one would also need a more objective source to complement this one. I think the bias of this website was especially obvious to me when I clicked on the "ads" tab (https://www.minimumwage.com/video-graphics/). Furthermore, a Google search about the Employment Policies Institute (the parent organization that created the minimum wage site) suggests that it actually might be an organization created by Rick Berman, a lobbyist for various private industries whose interests would be in conflict with raising the minimum wage (http://www.sourcewatch.org/index.php/Employment_Policies_Institute).

Emerging

This student argues that the source is not trustworthy based on the content of the article and the presence of attack ads on the site but does not investigate the trustworthiness of the organization or group behind MinimumWage.com.

This website introduces no new information on the subject and refuses to acknowledge the nuance of the subject. This website actually publishes attack ads on the subject of the minimum wage. It by no means can be called objective, and its facts shouldn't be trusted at face value. https://www.minimumwage.com/video-graphics/

Beginning

This student argues that the site is trustworthy based on its "non-profit" status and the "About" pages provided by MinimumWage.com and Employment Policies Institute.

I read the "About Us" page for MinimumWage.com and also for Employment Policies Institute. EPI sponsors MinimumWage.com and is a nonprofit research organization dedicated to studying policy issues surrounding employment, and it funds "nonpartisan" studies by economists around the nation. The fact that the organization is a non-profit, that it sponsors nonpartisan studies, and that it contains both pros and cons of raising the minimum wage on its website, makes me trust this source.

This student argues that the site is trustworthy based on the presence of links to articles from reliable sources like the New York Times.

> *My first response to this website is that it is not a reliable source since the domain is commercial, not governmental or organizational. However, after reading it I think it is reliable because it provides information with references to notable sources such as the New York Times.*

Claims on Social Media Rubric

This task presents students with a tweet from the liberal advocacy organization MoveOn.org that reads: "New polling shows the @NRA is out of touch with gun owners and their own members." The tweet contains a link to a press release by the poll's sponsor, the Center for American Progress, another liberal advocacy organization. Students are asked why this tweet might and might not be a useful source of information. Strong responses will note that the tweet may provide useful information given that it is based on a poll conducted by a professional polling firm. At the same time, students must acknowledge how the political alignment of the Center for American Progress and the political motivations of MoveOn.org, both of which support stronger gun control measures, may have shaped the structure of the poll and how its results were publicized.

Question 1: Why might this tweet be a useful source?

Mastery	Student fully explains that the tweet may be useful because it includes data from a poll conducted by a polling firm.
Emerging	Student addresses the polling data and/or the source of the polling data but does not fully explain how those elements may make the tweet useful.
Beginning	Student does not address the polling data or the source of the polling data as a reason the tweet may be useful.

Sample Responses

Mastery

This student identifies the polling firm and provides evidence of the firm's reliability.

> *The polling information which the tweet references was collected by Public Policy Polling, which appears to have a fairly strong accuracy record, though with a Democratic bent (e.g., Wall Street Journal article: http://www.wsj.com/articles/SB12259245556720280 5)*

Emerging

This student references the poll but does not explain why that makes the tweet a useful source of information.

> *The photo used in this tweet was compiled from a public policy polling survey.*

Beginning

This student focuses on the tweet's appearance rather than its content.

> *It could be useful because a graphic with a strong message can be enlightening or more likely thought provoking.*

This student equates Twitter followers with trustworthiness.

> *MoveOn.org has a large following on Twitter.*

Question 2: Why might this tweet not be a useful source?

Mastery	Student fully explains how the political motivations of the organizations involved may have influenced the content of the tweet and/or poll, which may make the tweet less useful.
Emerging	Student addresses the source of the tweet or the source of the news release but does not fully explain how those elements may make the tweet less useful.
Beginning	Student does not address the source of the tweet or the source of the news release as reasons the tweet may be less useful.

Sample Responses

Mastery

This student explains how MoveOn.org's work as a political advocacy organization might influence the tweet's contents.

> *According to the MoveOn.org Wikipedia page, MoveOn.org is a "progressive public policy" group and thus will most likely be against most any media or information distributed by the NRA. The criticisms section of the Wikipedia page cited more than one instance of MoveOn.org distorting the truth and even attempting to alter Google searches for their own benefit. I would seek a different source to know NRA members' opinions on background checks.*

Emerging

The student suggests that the tweet is politically motivated but does not explain how this might influence the content of the tweet.

> *Although MoveOn.org claims to be independent, they also were paid to work on Obama's campaign so are clearly Democrat-oriented, and the NRA members tend to be Republicans (http://front.moveon.org/about/#.V0NYK5MrLBI).*

Beginning

This student focuses on the nature of Twitter rather than the source of the tweet.

> *Twitter is a social platform built for sharing opinions, and though there are plenty of news organizations sharing facts on Twitter, I'd be more likely to trust an article than a tweet.*

Researching a Claim Rubric

This assessment asks students to perform an open search about whether birth control advocate and Planned Parenthood founder Margaret Sanger supported euthanasia. Googling "Margaret Sanger" and "euthanasia" turns up a welter of misrepresentation and hearsay, including from anti-Planned Parenthood sites like lifenews.com. By the end of her life, Sanger was a member of the Euthanasia Society of America. She supported the right to choose to end one's own life to stop pain and suffering. However, historians agree that Sanger never supported forced or state-sponsored euthanasia.

Successful students will locate evidence from a reliable source that sheds light on this question. Such evidence could include the passage from Sanger's book included in the Wikipedia citation, an article from New York University's Margaret Sanger Papers Project, or a searchable version of historian Ian Dowbiggin's *A Merciful End: The Euthanasia Movement in Modern America*. After locating evidence like this, strong responses explain how the information addresses the question and why the sources used are reliable.

Mastery	Student provides clear reasoning supported by evidence. Student provides evidence from a reliable source and considers the reliability of the source.
Partial Mastery	Student provides a clear answer supported by evidence. Student provides evidence from a reliable source but does not explicitly discuss its reliability, or the student does not provide a complete explanation.
Emerging	Student claims that there is no reliable evidence on the topic at hand.
Beginning	Student provides evidence from a potentially biased source with no consideration of reliability of the source or provides an irrelevant explanation.

Mastery

This student argues that Sanger did not support euthanasia. His evidence is a direct quote from Sanger, which the student located in an online book that he deemed trustworthy.

> *No, Sanger did not support euthanasia because she was quoted saying, "We [do not] believe that the community could or should send to the lethal chamber the defective progeny resulting from irresponsible and unintelligent breeding." It is in a book published by an award-winning, investigative journalist Edwin Black. (September 2003). The War Against the Weak: Eugenics and America's Campaign to Create a Master Race. New York City, NY: Four Walls Eight Windows. ISBN 1-56858-258-7., p. 251. Sanger's quote from The Pivot of Civilization, p. 100.*

Partial Mastery

This student argues that Sanger did not support euthanasia and provides a trustworthy source (the Margaret Sanger Papers Project at NYU) as evidence to support her reasoning. However, the student simply deems the source as "credible" without offering any explanation.

> *No, Sanger did not support euthanasia. I found a post from NYU, which was the only credible source I found, and it said that she did not publicly support euthanasia. https://www.nyu.edu/projects/sanger/articles/keller.php.*

Emerging

This student dismisses the claim that Sanger supported euthanasia because he could not locate evidence he considered trustworthy; however, he did not find any reliable evidence to support his argument.

> *I do not believe that there are credible sources saying that Margaret Sanger supported euthanasia; therefore, I cannot support the claim that Margaret Sanger supported euthanasia.*

Beginning

This student argues that Sanger did support euthanasia but uses biased sources as evidence without considering their trustworthiness.

> *From the research that I did, I believe that Margaret Sanger did support euthanasia. Many different articles including http://liveaction.org/blog/racist-planned-parenthood-founder-margaret-sanger-was-not-so-pro-choice/ show the different sides, but give much more evidence supporting the claim that Sanger did support euthanasia. This article provided a letter from Margaret Sanger that included a statement supporting euthanasia.*

This student argues that Sanger did support euthanasia but provides only URLs with no explanation about what the sources argue or why they are trustworthy.

> *Yes, she did support euthanasia: http://www.lifenews.com/2014/04/02/just-discovered-letter-shows-margaret-sanger-was-part-of-euthanasia-society/ https://www.lifesitenews.com/opinion/7-shocking-quotes-by-planned-parenthood-founder-margaret-sanger*

Appendix B

Descriptive Statistics Including Mean, Skewness, and Kurtosis for SDLRS

Factor	Item	*M*	Std. Dev	Skewness	Kurtosis
DFL, LSE	I want to learn new information.	4.64	0.62	-1.86	6.83
DFL, CSE[a]	I like to evaluate what I do.	4.62	0.55	-1.05	3.06
DFL, LSE	I learn from my mistakes.	4.46	0.61	-1.05	4.99
DFL	I critically evaluate new ideas.	4.30	0.79	-1.13	4.06
DFL, LSE	I enjoy learning new information.	4.54	0.70	-2.22	10.76
DFL, LSE	I need to know why.	4.46	0.63	-1.10	4.71
DFL, LSE	When presented with a problem I cannot resolve, I will ask for assistance.	4.48	0.82	-1.73	5.56
DFL, LSE[a]	I am open to new ideas.	4.55	0.63	-1.43	5.44
DFL	I do not enjoy studying.	3.16	1.29	-0.34	2.05
DFL, CSE[a]	I like to gather facts before I make a decision.	4.54	0.63	-1.37	5.28
DFL, LSE	I have a need to learn.	4.23	0.97	-1.44	4.58
DFL, LSE	I enjoy a challenge.	4.28	0.89	-1.20	3.74
SC, SD[a]	I prefer to set my own goals.	4.45	0.58	-0.48	2.29
SC, LSE	I have high personal standards.	4.55	0.63	-1.43	5.44
SC, LSE	I can find out information for myself.	4.54	0.56	-0.66	2.35
SC, SD[a]	I prefer to set my own criteria on which to evaluate my performance.	3.54	1.01	-0.01	1.93
SC, LSE[a]	I have high personal expectations.	4.58	0.67	-1.60	5.28
SC, CSE[a]	I am logical.	4.29	0.71	-1.22	5.45
SC, LSE	I am able to focus on a problem.	4.38	0.75	-1.16	4.14
SC, LSE	I am responsible for my own decisions/actions.	4.86	0.35	-2.02	5.07

Note. [a] Not included in the 29-item SDLRS.

Factor	Item	*M*	Std. Dev	Skewness	Kurtosis
SC, LSE	I have high beliefs in my abilities.	4.28	0.82	-1.51	6.18
SC, LSE	I am responsible.	4.52	0.56	-0.60	2.28
SC, LSE[a]	I like to make decisions for myself.	4.70	0.49	-1.21	3.29
SC, CSE	I evaluate my own performance.	4.41	0.75	-1.03	3.24
SC, LSE	I am not in control of my life.	3.91	1.17	-1.26	3.74
SC, SD	I prefer to set my own learning goals.	4.13	0.84	-0.85	3.31
SC	I am aware of my own limitations.	4.30	0.60	-0.64	4.58
SM, EOL	I am systematic in my learning.	4.12	0.98	-0.90	2.79
SM[a]	I solve problems using a plan.	4.01	0.96	-0.63	2.38
SM, SD[a]	I prefer to plan my own learning.	4.01	0.80	-0.73	3.45
SM, EOL[a]	I have good management skills.	4.07	0.85	-1.02	4.54
SM, EOL	I set strict time frames.	3.41	1.14	-0.30	2.11
SM	I can be trusted to pursue my own learning.	4.25	0.77	-1.03	4.04
SM, EOL	I am disorganized.	3.52	1.27	-0.49	2.08
SM, EOL	I am self disciplined.	4.22	0.91	-1.28	4.59
SM, EOL	I prioritize my work.	4.20	0.85	-0.98	3.44
SM, EOL	I set specific times for my study.	3.20	1.29	-0.09	1.89
SM, LSE	I am confident in my ability to search out new information.	4.38	0.64	-0.86	4.17
SM, CSE	I am methodical.	4.09	0.98	-1.21	4.34
SM, EOL[a]	I do not manage my time well.	3.55	1.11	-0.56	2.50

Note. [a] Not included in the 29-item SDLRS.

Appendix C

Survey Instrument

Informed Consent

AUBURN UNIVERSITY

COLLEGE OF EDUCATION

EDUCATIONAL FOUNDATIONS, LEADERSHIP AND TECHNOLOGY

(NOTE: DO NOT AGREE TO PARTICIPATE UNLESS IRB APPROVAL
INFORMATION WITH CURRENT DATES HAS BEEN ADDED TO THIS DOCUMENT.)

INFORMATION LETTER
for a Research Study entitled
"Relational Reasoning and Self-Directed Learning: An Analysis of Their Effect on How Adults Process Information Online"

You are invited to participate in a research study to understand how relational reasoning and self-directed learning influence the way adults interact with information online. The study is being conducted by Daniel Harris, PhD student, under the direction of Dr. David Shannon, Hermana-Germany-Sherman Distinguished Professor in the Auburn University Department of Educational Foundations, Leadership, and Technology. You are invited to participate because you are at student at Squadron Officer School and are age 19 or older.

What will be involved if you participate? Your participation is completely voluntary. If you

based survey hosted by Qualtrics, which Auburn University is an official license holder. Your total time commitment will be approximately 60 minutes.

Are there any risks or discomforts? There are no foreseeable risks associated with participating in this study.

Will you receive compensation for participating? To thank you for your time you will be given the opportunity to receive a $5 Starbucks gift card upon completion of the survey.

If you change your mind about participating, you can withdraw at any time by not clicking on the **Continue** button below or simply closing out of the web-based survey program. Once you've submitted anonymous data, it cannot be withdrawn since it will be unidentifiable. Your decision about whether to participate or to stop participating will not jeopardize your future relations with Auburn University, the College of Education, and the Department of Educational Foundations, Leadership, and Technology.

Any data obtained in connection with this study will remain anonymous. We will protect your privacy and the data you provide will be stored with password protection. Information collected through your participation will be used to fulfill an academic requirement and couple possibly be used to be published in an academic journal and/or be presented at a professional conference. No individual data will be reported to Squadron Officer school or to the Air Force. Only aggregated information will be shared with Squadron Officer School and the Air Force to ensure the confidentiality of participants

Note: The DoD will have access to study records to ensure subject's safety and regulatory compliance.

If you have questions about this study, please contact Daniel Harris at dzh0056@auburn.edu, or David Shannon at shannondm@auburn.edu.

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334) 844-5966 or e-mail at IRBadmin@auburn.edu or IRBChair@auburn.edu.

HAVING READ THE INFORMATION ABOVE, YOU MUST DECIDE IF YOU WANT TO PARTICIPATE IN THIS RESEARCH PROJECT. IF YOU DECIDE TO PARTICIPATE, PLEASE CLICK ON THE LINK BELOW. YOU MAY PRINT A COPY OF THIS LETTER TO KEEP.

Daniel A. Harris

The Auburn University Institutional Review Board has approved this document for use from 10/27/2021 to -------. Protocol #21-472 EP 2110

Version Date (date document created): 10/27/2021

The Auburn University Institutional Review Board has approved this Document for use from 10/27/2021 to ------- Protocol # 21-472 EP 2110

Demographic and academic information

The following questions will be used to gain insight into your background. Please answer all questions to the best of your ability. Your answers will remain completely anonymous.

What is your age in years?

How do you currently describe your gender identity?

With which racial/ethnic group(s) do you identify?
(Please mark all that apply.)

- [ ] American Indian or Alaska Native (e.g., Navajo Nation, Blackfeet Tribe, Mayan, Aztec, Native Village of Barrow Inupiat Traditional Government, Nome Eskimo Community)
- [ ] Asian (e.g., Chinese, Filipino, Asian Indian, Vietnamese, Korean, Japanese)
- [ ] Black or African American (e.g., Jamaican, Haitian, Nigerian, Ethiopian, Somalian)
- [ ] Hispanic, Latino, or Spanish Origin (e.g., Mexican or Mexican American, Puerto Rican, Cuban, Salvadoran, Dominican, Columbian)
- [ ] Middle Eastern or North African (e.g., Lebanese, Iranian, Egyptian, Syrian, Moroccan, Algerian)
- [ ] Native Hawaiian or Other Pacific Islander (e.g., Native Hawaiian, Samoan, Guamanian, Chamorro, Tongan, Fijian, Marshallese)
- [ ] White (e.g., German, Irish, English, Italian, Polish, French)
- [ ] Another race/ethnicity not listed. *(Please describe.)*
- [ ] I prefer not to answer

What is the highest level of education you have completed?

- ○ Bachelor's degree (e.g., BA, BBA, BFA, BS)
- ○ Some post undergraduate work
- ○ Master's degree (e.g., MA, MBA, MFA, MS, MSW)
- ○ Specialist degree (e.g., EdS)
- ○ Applied or professional doctorate degree (e.g., MD, DDC, DDS, JD, PhamD)
- ○ Doctorate degree (e.g., EdD, PhD)
- ○ Other *(Please Describe)*

What is your primary AFSC?

Civic Online Reasoning

The next three tasks deal with information from common online sources. The prompts will ask

you to spend a couple of minutes answering the questions. You may use any additional websites you wish, just open them up in a new browser window or tab. Click the **Continue** button to move on to the next page.

Article Analysis

Take about 5 minutes to complete this task. Visit the following webpage in a new browser window or tab:
https://www.minimumwage.com/2014/10/denmarks-dollar-forty-one-menu/

Is this a reliable source of information about the minimum wage? You may use any information on this website, or you can open a new tab and do an Internet search if you want.

Explain your answer, citing evidence from the webpages you used. Be sure to provide the URLs to the webpages you cite.

Claims on Social Media

Take about 5 minutes to complete this task. The following tweet appears in your Twitter feed (shown below, or open in a new browser window or tab):
https://twitter.com/MoveOn/status/666772893846675456?lang=en

Why might this tweet be a useful source about NRA members' opinions on background checks? List any sources you used to make your decision.

Why might this tweet not be a useful source about NRA members' opinions on background checks? List any sources you used to make your decision.

Researching a Claim

Some people claim that Margaret Sanger, the founder of Planned Parenthood, supported euthanasia. Take about 8 minutes doing research online to decide if you believe this claim is true. Open any websites you choose to use in a new browser window or tab.

Do you believe Margaret Sanger supported euthanasia? Explain using evidence from the websites you consulted.

Explain why the sources you used are strong.

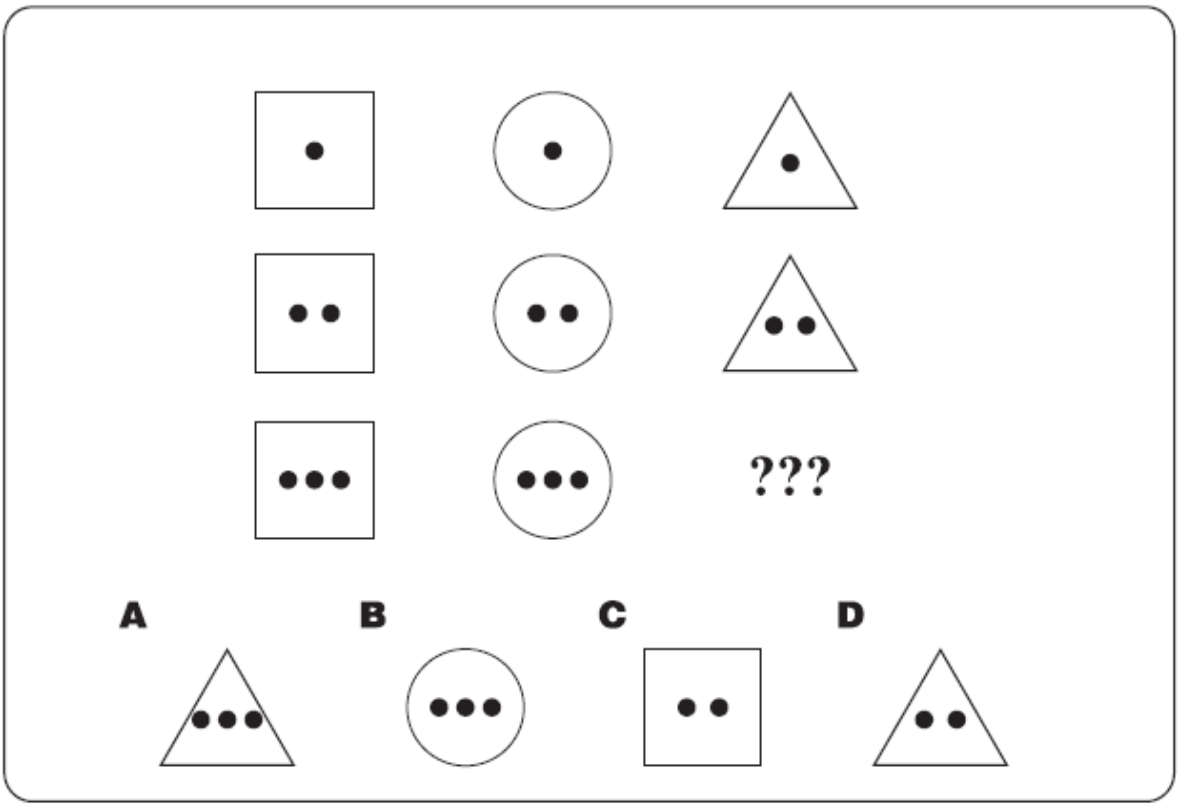
TORR Instructions

This portion of the survey is the Test of Relational Reasoning. Relational reasoning is an important cognitive process used for learning. In this portion, you will experience four separate sections that each examine a different form of relational reasoning. When going through the study, try to remain focused, and do your best to answer every question. You can expect it to take about 35 minutes.

Click the **Continue** button to move on to the next page. Be sure to read and follow all instructions carefully.

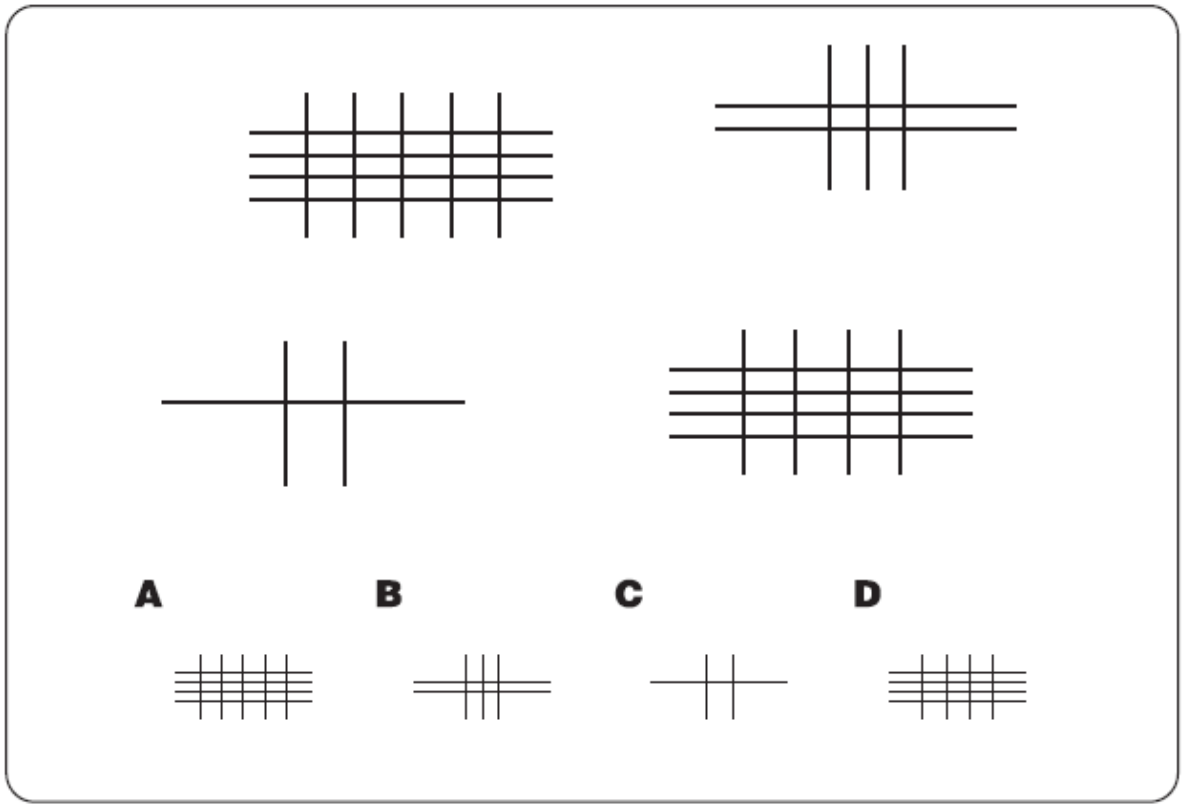
Directions: *Below is a pattern that is not yet complete.*
Select the figure from those shown below that completes the pattern.

Sample 1



Directions: *All these figures* ***but one*** *follow a particular pattern or rule.* **Find the one figure that does not follow the pattern.**

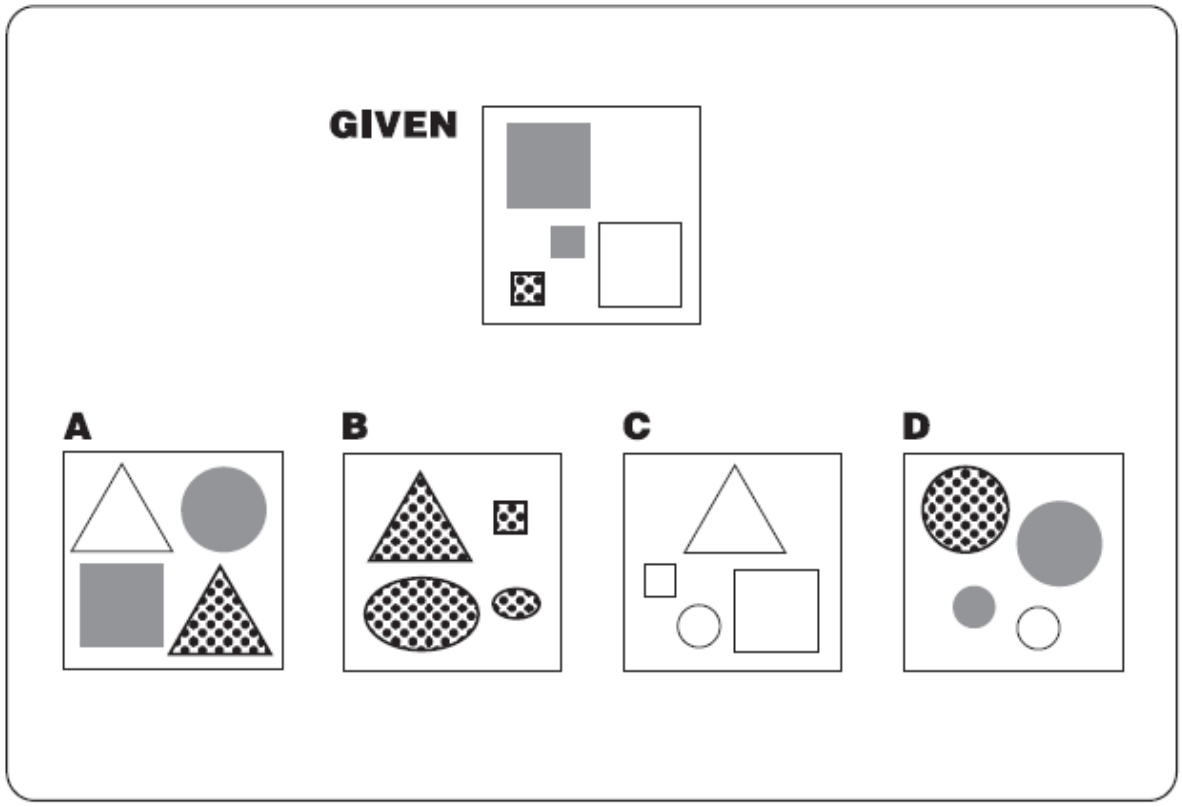
Sample 1



Directions:

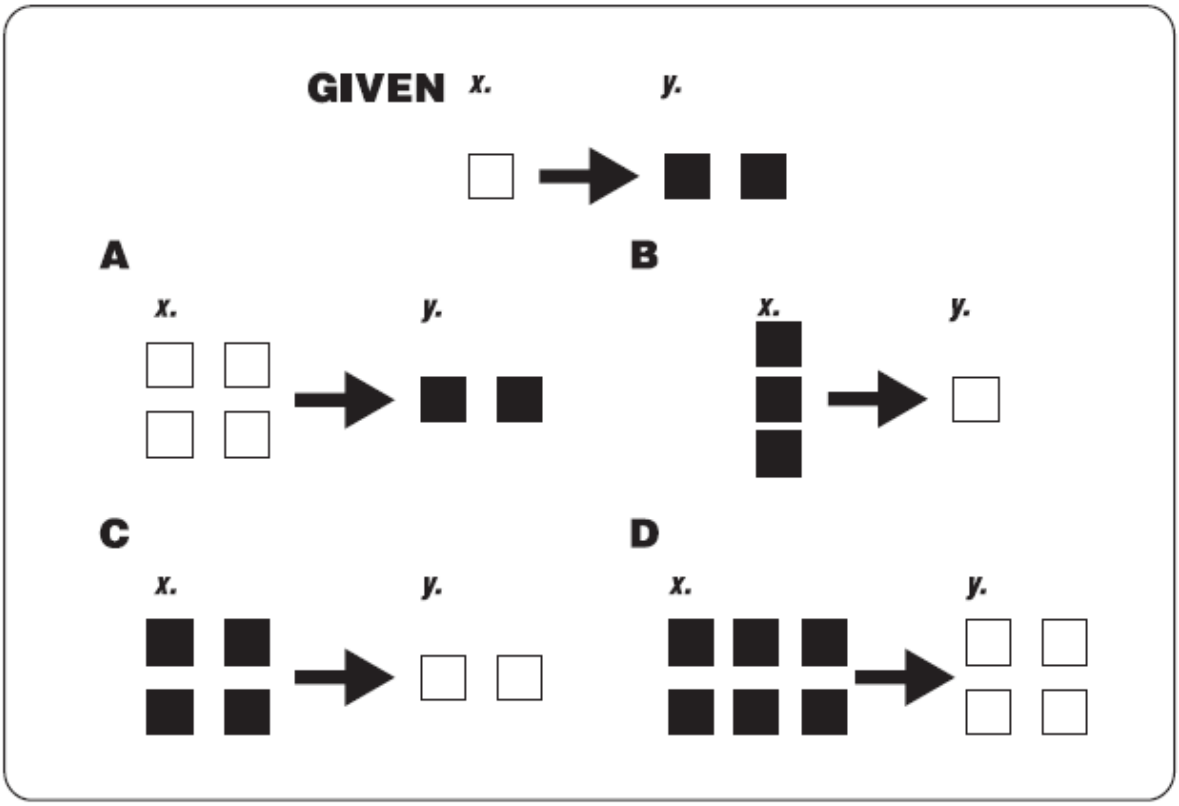
- **The problems in this section ask you to compare sets of objects that vary in certain features.**
- **Each set has a specific rule that decides what objects can be included in that set. Some of the objects included in each set are pictured, enough to allow you to determine its rule for inclusion.**
- **Every problem asks you to identify which ONE of the four sets that are shown could NEVER have an object in common with the Given set, based on the compatibility of their rules for inclusion.**
- **There will always be EXACTLY ONE set that is incompatible with the Given set.**

Sample 1



Directions: The given figure below depicts a ***process*** in which X becomes Y. In the figure, the arrow represents the rule by which the change occurs. Select the answer choice that shows the ***opposite*** of the given process.

Sample 1



SDLR Intro

This is the final section of the survey. It should take you about 10 minutes to complete. The following questions ask about your beliefs and attitudes. There are no right or wrong answers.

Click the **Continue** button to move on to the next page. Be sure to read and follow all instructions carefully.

Self Directed Learning Readiness

Choose the option that best describes your level of agreement with the statement.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
Please select "Somewhat disagree" for this item.	○	○	○	○	○
I want to learn new information.	○	○	○	○	○
I like to evaluate what I do.	○	○	○	○	○
I learn from my mistakes.	○	○	○	○	○
I prefer to set my own goals.	○	○	○	○	○
I am systematic in my learning.	○	○	○	○	○
I solve problems using a plan.	○	○	○	○	○
I have high personal standards.	○	○	○	○	○
I can find out information for myself.	○	○	○	○	○

Choose the option that best describes your level of agreement with the statement.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
I prefer to plan my own learning.	○	○	○	○	○
I prefer to set my own criteria on which to evaluate my performance.	○	○	○	○	○
I critically evaluate new ideas.	○	○	○	○	○
I have good management skills.	○	○	○	○	○
I enjoy learning new information.	○	○	○	○	○
I have high personal expectations.	○	○	○	○	○
I am logical.	○	○	○	○	○
I need to know why.	○	○	○	○	○

Choose the option that best describes your level of agreement with the statement.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
Please select "Somewhat agree" for this item.	○	○	○	○	○
I am able to focus on a problem.	○	○	○	○	○
I am responsible for my own decisions/actions.	○	○	○	○	○
I have high beliefs in my abilities.	○	○	○	○	○
I set strict time frames.	○	○	○	○	○
I can be trusted to pursue my own learning.	○	○	○	○	○
When presented with a problem I cannot resolve, I will ask for assistance.	○	○	○	○	○
I am disorganized.	○	○	○	○	○
I am responsible.	○	○	○	○	○

Choose the option that best describes your level of agreement with the statement.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
I like to make decisions for myself.	○	○	○	○	○
I am open to new ideas.	○	○	○	○	○
I am self disciplined.	○	○	○	○	○
I prioritize my work.	○	○	○	○	○
I do not enjoy studying.	○	○	○	○	○
I like to gather facts before I make a decision.	○	○	○	○	○
I evaluate my own performance.	○	○	○	○	○
I set specific times for my study.	○	○	○	○	○

Choose the option that best describes your level of agreement with the statement.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
I am not in control of my life.	○	○	○	○	○
I am confident in my ability to search out new information.	○	○	○	○	○
I have a need to learn.	○	○	○	○	○
I am methodical.	○	○	○	○	○
I enjoy a challenge.	○	○	○	○	○
I prefer to set my own learning goals.	○	○	○	○	○
I am aware of my own limitations.	○	○	○	○	○
I do not manage my time well.	○	○	○	○	○

Gift Card Giveaway

Would you like to receive a $5 Starbucks gift card as a thank you for your participation?

○ Yes

○ No

Appendix D

Institutional Review Board Approval Email

Harris Approval, Protocol #21-472 EP 2110 "Relational Reasoning and Self-Directed Learning: An Analysis of Their Effect on How Adults Process Information Online"

IRB Administration <irbadmin@auburn.edu>
Mon 11/15/2021 8:09 AM
To: Daniel Harris <dzh0056@auburn.edu>
Cc: David Shannon <shanndm@auburn.edu>;James Satterfield <jws0089@auburn.edu>

2 attachments (5 MB)
Investigators Responsibilities rev 1-2011.docx; Harris 21-472 EP 2110 new revisions 1.pdf;

Use IRBsubmit@auburn.edu for protocol-related submissions and IRBadmin@auburn.edu for questions and information.
The IRB only accepts forms posted at https://cws.auburn.edu/vpr/compliance/humansubjects/?Forms and submitted electronically.

Dear Daniel,

The protocol "Relational Reasoning and Self-Directed Learning: An Analysis of Their Effect on How Adults Process Information Online" was approved as "Expedited" under federal regulation 45 CFR 46.110(b)(7). Attached is a copy of your IRB-stamped protocol.

Official notice:
This e-mail serves as official notice the protocol has been approved. By accepting this approval, you also accept your responsibilities associated with this approval. Details of your responsibilities are attached. Retain for your records.

Expiration:
Continuing review of this Expedited protocol is not required; however, all modification/revisions to the approved protocol must be reviewed and approved by the IRB.

When you have completed all research activities, have no plans to collect additional data and have destroyed all identifiable information as approved by the IRB, please submit a final report.

PLEASE NOTE: If any unfunded, IRB-approved study should later receive funding, you must submit a MODIFICATION REQUEST for IRB review. In the request, identify the funding source/sponsor and AU OSP number. Also, revise IRB-stamped consent documents to include the Sponsor at the top of page 1 and the "Who will see study data?" section of consent documents." (see online template consent documents).

Best wishes for success with your research!

IRB Admin
Office of Research Compliance
115 Ramsay Hall
Auburn University
Auburn, AL

Harris Modification Request - Approved Protocol, #21-472 EP 2110 "Relational Reasoning and Self-Directed Learning: An Analysis of Their Effect on How Adults Process Information Online"

IRB Administration <irbadmin@auburn.edu>
Wed 2/16/2022 12:05 PM

To: Daniel Harris <dzh0056@auburn.edu>

Cc: David Shannon <shanndm@auburn.edu>;James Satterfield <jws0089@auburn.edu>

Use IRB Submission Page for protocol-related submissions and IRBadmin@auburn.edu for questions and information.

Dear Daniel,

The requested modification for "Relational Reasoning and Self-Directed Learning: An Analysis of Their Effect on How Adults Process Information Online" was reviewed and approved. The review category is now approved as "EP" under federal regulation 45 CFR 46.110(7). Attached is a copy of the IRB-stamped documents.

Official notice:
This e-mail serves as official notice of approval to requested modifications. By accepting this approval, you also acknowledge your responsibilities associated with this approval. Retain a copy of the attached details of your responsibilities.

Consent documents:
Attached is a copy of your consent document. You must provide a copy for each participant to keep.

Expiration:
Continuing review of this Expedited protocol is not required; however, all modification/revisions to the approved protocol must be reviewed and approved by the IRB.

When you have completed all research activities, have no plans to collect additional data and have destroyed all identifiable information as approved by the IRB, please submit a final report.

PLEASE NOTE: If any unfunded, IRB-approved study should later receive funding, you must submit a MODIFICATION REQUEST for IRB review. In the request, identify the funding source/sponsor and AU OSP number. Also, revise IRB-stamped consent documents to include the Sponsor at the top of page 1 and the "Who will see study data?" section of consent documents." (see online template consent documents).

Best wishes for success with your research,

IRB Administration
Office of Research Compliance
540 Devall Drive
Auburn University
Auburn, AL

Appendix E

Air Force Human Resource Protection Official Approval

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY (AETC)

MEMORANDUM FOR AUBURN UNIVERSITY

06 DECEMBER 2021

ATTN: DANIEL HARRIS
DR. YOLANDA WILLIAMS
DR. CLIFFORD MOSLEY

FROM: HRPO DELEGATE
Dr. Jendia Grissett
Air University
55 Lemay Plaza South
Maxwell, AFB 36112

SUBJECT: Human Research Protection Official (HRPO) Review of FAU 2021-0002

References: *(a)* Department of Defense Instruction 3216.02_Air Force Instruction 40-402, 14 September 2014, *Protection of Human Subjects and Adherence to Ethical Standards in Air Force Supported Research*
(b) Department of Defense Instruction 3216.02, 15 April 2020, *Protection of Human Subjects and Adherence to Ethical Standards in DoD-Supported Research*
(c) 32 CFR 219, *Protection of Human Subjects*

1. In accordance with References (a)-(b), the HRPO has reviewed and **approves** the following protocol: Auburn University, (21-472 EP2110) approved 10/27/2021: *"Relational Reasoning and Self-Directed Learning: An Analysis of Their Effect on How Adults Process Information Online."*

2. The HRPO concurs with Auburn University's IRB determination as "Expedited, Category 7," specifically 45 CFR 46.110.

3. Please ensure this research is conducted in compliance with the References, including Reference (c), as it pertains to submission of continuing review reports, proper maintenance of records, and the application of written informed consent to all study participants, as required by the IRB.

4. Contact Dr. Jendia Grissett (jendia.grissett@us.af.mil) to discuss any substantive change to this activity, such as the recruitment of any military populations, prior to implementation and to ensure it does not impact the determination herein or compliance with the above references.

5. In addition, please refer to the Terms of Air Force HRPO Concurrence (attached) regarding reporting requirements and responsibilities of the Principal Investigator to the HRPO. Failure to comply could result in the suspension of Air Force support for this research activity.

Dr. Jendia Grissett
HRPO, HRPP POC
Air University

GRISSETT.JENDI A.F.1205019355

1 Attachment:
1. Terms of AF HRPO Approval

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY (AETC)

MEMORANDUM FOR AUBURN UNIVERSITY

20 March 2022

ATTN:
DANIEL HARRIS
DR. YOLANDA WILLIAMS, AIO
DR. CLIFFORD MOSLEY
DR. BART KESSLER

FROM: HRPO DELEGATE
Dr. Jendia Grissett
Air University
55 Lemay Plaza South
Maxwell, AFB 36112

SUBJECT: Human Research Protection Official (HRPO) Review of changes to FAU 2021-0002v.1, "Relational Reasoning and Self-Directed Learning: An Analysis of Their Effect on How Adults Process Information Online."

References:
(a) Department of Defense Instruction 3216.02_Air Force Instruction 40-402,14 September 2014, *Protection of Human Subjects and Adherence to Ethical Standards in Air Force Supported Research*
(b) Department of Defense Instruction 3216.02, 15 April 2020, *Protection of Human Subjects and Adherence to Ethical Standards in DoD-Supported Research*
(c) 32 CFR 219, *Protection of Human Subjects.*

1. In accordance with References (a)-(b), the HRPO has reviewed and approves the revisions to the following protocol: Auburn University, (21-472 EP2110) approved 10/27/2021: "Relational Reasoning and Self-Directed Learning: An Analysis of Their Effect on How Adults Process Information Online."
2. The HRPO concurs with Auburn University's IRB determination as "Expedited, Category 7," specifically 45 CFR 46.110, and acknowledges Auburn University's acceptance of changes dated 9 February 2022. The changes made to the previous protocol include changes to the population and recruiting materials. Population expanded to include Air University's Global College with Commander approval.
3. Please ensure this research is conducted in compliance with the References, including Reference (c), as it pertains to submission of continuing review reports, proper maintenance of records, and the application of written informed consent to all study participants, as required by the IRB. Please submit the final study to the HRPO upon study closure as outlined in DoDI 3216.02 section 3.6, *DoD Support Research*: b, *DoD Oversight and Approval*: (6)(d))(1-8).

4. Contact Dr. Jendia Grissett (jendia.grissett@us.af.mil) to discuss any substantive change to this activity, such as the recruitment of any military populations, prior to implementation and to ensure it does not impact the determination herein or compliance with the above references.
5. In addition, please refer to the Terms of Air Force HRPO Concurrence (attached) regarding reporting requirements and responsibilities of the Principal Investigator to the HRPO. Failure to comply could result in the suspension of Air Force support for this research activity.

Dr. Jendia Grissett, HRPO,

GRISSETT.JENDI A.F.1205019355

HRPP POC Air University

1 Attachment: 1. Terms of AF HRPO Approval

Appendix F

DEPARTMENT OF THE AIR FORCE
SQUADRON OFFICER SCHOOL (AETC)
MAXWELL AIR FORCE BASE ALABAMA

22 September 2021

MEMORANDUM FOR THE OFFICE OF RESEARCH COMPLIANCE, AUBURN UNIVERSITY

FROM: Squadron Officer School
125 Chennault Circle
Maxwell AFB, AL 36112

SUBJECT: Permission to Access and Use Documentation and Data Needed to Conduct Dissertation Research

1. This letter affirms Squadron Officer School's support to provide access to voluntary student participation for the proposed research study by Auburn University, College of Education Ph.D. student, Major Daniel Harris. The proposed research titled, "Relational Reasoning and Self-Directed Learning: An Analysis of Their Effect on How Adults Process Information Online," is a quantitative study using survey data to explore how relational-reasoning skills and self-directed learning characteristics influence how adults interact with information online. Squadron Officer School considers the proposed research valuable to the organization due to its potential to provide information about the extent of reasoning skills in our student population. The research may also suggest additional ways to improve those skills in our students.

2. To support the research proposal and maintain participant confidentiality, the researcher will not collect directly identifiable data about the participants. The survey responses will be aggregated, and individual responses will not be reported. In addition, the researcher will not attribute or specify the Squadron Officer School organization in any research findings or conclusion produced.

3. Squadron Officer School's support is contingent upon the review and approval of the human subject's protection protocol by Auburn University's Institutional Review Board, and the subsequent review by Air University officials and the Department of Defense's Human Research Protection Office. After these approvals, Squadron Officer School will provide the researcher access to volunteer student participants. The survey questions will be unclassified.

4. If you have any questions, please contact me at [redacted] or klifford.mosley@au.af.edu.

Recoverable Signature

X Klifford W. Mosley

KLIFFORD W. MOSLEY, Lt Col, PhD, USAF
Dean
Signed by: MOSLEY.KLIFFORD.W.1109693096

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY (AETC)

3 February 2022

MEMORANDUM FOR The Office of Research Compliance at Auburn University

FROM: eSchool of Graduate PME
51 East Maxwell Boulevard
Maxwell AFB, AL 36112

SUBJECT: Permission to Access and Use Documentation and Data Needed to Conduct Dissertation Research

1. This letter affirms the eSchool of Graduate PME's (eSchool) support to provide access to voluntary student participation for the proposed research study by Auburn University, College of Education Ph.D. student, Maj Daniel Harris. The proposed research titled, "Relational Reasoning and Self-Directed Learning: An Analysis of Their Effect on How Adults Process Information Online," is a quantitative study using survey data to explore how relational reasoning skills and self-directed learning characteristics influence how adults interact with information online. The eSchool considers the proposed research valuable to the organization due to its potential to provide information about the extent of reasoning skills in the student population. The research may also suggest additional ways to improve those skills in the students.

2. To support the research proposal and maintain participant anonymity, the researcher will not collect directly identifiable data about the participants. The survey responses will be aggregated, and individual responses will not be reported. In addition, the researcher will not attribute or specify the eSchool organization in any research findings or conclusion produced.

3. The eSchool's support is contingent upon the review and approval of the human subject's protection protocol by Auburn University's Institutional review board and the subsequent review by the Department of Defense's Human Research Protection Office. After these approvals, the eSchool will provide the researcher access to volunteer student participants. The survey questions will be unclassified.

4. If you have any questions, please contact Lt Col Dwayne Clark, Director, Design and Development, at Dwayne.clark@au.af.edu.

RAMSEY.CRAIG.M.1059987549
Digitally signed by RAMSEY.CRAIG.M.1059987549
Date: 2022.02.03 11:32:11 -06'00'

CRAIG M. RAMSEY, Colonel, USAF
Commandant

Appendix G

Participant Information Letter and Recruitment Materials

In-residence Canvas Recruitment Letters

Canvas announcement title/Canvas message subject: Research study opportunity and $5 Starbucks gift card!

Dear SOS Student:

You are invited to participate in an Auburn University doctoral research study aimed at understanding how relational reasoning and self-directed learning influence the way adults interact with information online. The study is being conducted by Daniel Harris, PhD student, under the direction of Dr. David Shannon, Hermana-Germany-Sherman Distinguished Professor in the Auburn University Department of Educational Foundations, Leadership, and Technology.

You participation is completely voluntary. You are invited to participate because you are an SOS student. If you choose to participate you will be asked to take a web-based survey which will take approximately 60 minutes to complete. All information will be summarized by groups, so that no individual answers will be identifiable. Additionally, the responses will be completely anonymous.

After completion of the web-based survey, you will receive a $5 Starbucks gift card. If you choose not to participate in the study, you can withdraw at any time by not clicking on the link below or by simply closing out of the web-based survey program. Either way, your data will not be collected. However, one you've submitted anonymous data, it cannot be withdrawn since it will be unidentifiable. Your decision about whether to participate or to stop participating will not be jeopardize your future relations with Auburn University, the College of Education, or the Department of Educational Foundations, Leadership, and Technology.

To participate in the study and complete the survey, please follow this link:
Take the survey
Or copy and paste the URL below into your internet browser:
https://aub.ie/vc624W

Sincerely,
Dan Harris
PhD Student
Auburn University
College of Education
Department of Educational Foundations, Leadership, and Technology
Auburn University, AL 36849

Canvas announcement title/Canvas message subject: Research study opportunity and $5 Starbucks gift card!

Dear SOS Student,

If you haven't already done so, you are invited to participate in an Auburn University doctoral research study aimed at understanding how relational reasoning and self-directed learning influence the way adults interact with information online. The study is being conducted by Daniel Harris, PhD student, under the direction of Dr. David Shannon, Hermana-Germany-Sherman Distinguished Professor in the Auburn University Department of Educational Foundations, Leadership, and Technology.

Your participation is completely voluntary. You are invited to participate because you are an SOS student. If you choose to participate, you will be asked to take a web-based survey which will take approximately 60 minutes to complete. All information will be summarized by groups so that no individual answers will be identifiable. Additionally, the responses will be completely anonymous.

After completing the web-based survey, you will have the option to receive a $5 Starbucks gift card. If you choose not to participate in the study, you can withdraw at any time by not clicking on the link below or by simply closing out of the web-based survey program. Either way, your data will not be collected. However, once you've submitted anonymous data, it cannot be withdrawn since it will be unidentifiable. Your decision about whether to participate or to stop participating will not jeopardize your future relations with Auburn University, the College of Education, or the Department of Educational Foundations, Leadership, and Technology.

To participate in the study and complete the survey, please follow this link:
Take the survey
Or copy and paste the URL below into your internet browser:
https://aub.ie/vc624W

Sincerely,
Dan Harris
PhD Student
Auburn University
College of Education
Department of Educational Foundations, Leadership, and Technology
Auburn University, AL 36849

Canvas announcement title/Canvas message subject: Last chance! Research study opportunity and $5 Starbucks gift card!

Dear SOS Student,
This is your last chance to participate in a research study and receive a Starbucks gift card. If you haven't already done so, you are invited to participate in an Auburn University doctoral research study aimed at understanding how relational reasoning and self-directed learning influence the way adults interact with information online. The study is being conducted by Daniel Harris, PhD student, under the direction of Dr. David Shannon, Hermana-Germany-Sherman Distinguished Professor in the Auburn University Department of Educational Foundations, Leadership, and Technology.

You participation is completely voluntary. You are invited to participate because you are an SOS student. If you choose to participate you will be asked to take a web-based survey which will take approximately 60 minutes to complete. All information will be summarized by groups, so that no individual answers will be identifiable. Additionally, the responses will be completely anonymous.

After completion of the web-based survey, you will have the option receive a $5 Starbucks gift card. If you choose not to participate in the study, you can withdraw at any time by not clicking on the link below or by simply closing out of the web-based survey program. Either way, your data will not be collected. However, one you've submitted anonymous data, it cannot be withdrawn since it will be unidentifiable. Your decision about whether to participate or to stop participating will not be jeopardize your future relations with Auburn University, the College of Education, or the Department of Educational Foundations, Leadership, and Technology.

To participate in the study and complete the survey, please follow this link:
Take the survey
Or copy and paste the URL below into your internet browser:
https://aub.ie/vc624W

Sincerely,
Dan Harris
PhD Student
Auburn University
College of Education
Department of Educational Foundations, Leadership, and Technology
Auburn University, AL 36849

In-residence Recruitment Flyer

The survey will take ~60 minutes. Please take the survey on a computer.

Link to survey:
https://aub.ie/vc624W

For more information watch this video
https://aub.ie/4W4g4a

Research Study on Online Information Processing

We live in a complex social environment, and we deal with a flood of information on the internet. The purpose of this research study is to examine how adults process that information in order to make judgements about the world. All SOS students are invited to take part in this voluntary survey.

If you choose to participate, you will receive a $5 Starbucks gift card as a thank you.

This study is being conducted by Dan Harris, a PhD student at Auburn University. Please contact me at dzhoo56@auburn.edu for more information.

The Auburn University Institutional Review Board has approved this Document for use from
10/27/2021 to -------
Protocol # 21-472 EP 2110

Version date: October 1, 2021

Asynchronous Course Recruitment Letters

Ulis message subject: Research study opportunity and $5 Starbucks gift card!

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For more information about the purpose of the research, watch this video:
https://aub.ie/inwN3f

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If you want to participate, you must take the survey outside of duty hours. To participate in the study and complete the survey, please follow this link:
Take the survey
Or copy and paste the URL below into your internet browser:
https://aub.ie/Y1uryd

Sincerely,
Dan Harris
PhD Student
Auburn University
College of Education
Department of Educational Foundations, Leadership, and Technology
Auburn University, AL 36849

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https://aub.ie/Y1uryd

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