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Dimensional comparison occurs when people compare their status in one domain (e.g., math) to their status in another domain (e.g., verbal). This comparison may result in a contrast effect in which self-concepts in the superior domain become inflated and self-concepts in the inferior domain becomes deflated. Alternatively, the comparison may result in an assimilation effect with the opposite outcome: self-concepts in the superior domain become deflated and self-concepts in the inferior domain becomes inflated. Presently, the factors that cause dimensional comparisons to result in either assimilation or contrast effects remain unclear. I argue that dimensional comparisons result in assimilation effects when people believe that standing in the two domains is positively interdependent (i.e., high status in one domain predicts high status in the other domain) and contrast effects when people believe that standing in the two domains is negatively interdependent (i.e., high status in one domain predicts low status in the other). In three experiments using 3 different manipulations, I tested whether these domain interdependence beliefs (DIBs) are a primary mechanism underlying dimensional comparison effects. I predicted that participants who are manipulated to have negative math/verbal DIBs would display dimensional comparison contrast, while those manipulated to have positive math/verbal DIBs would display dimensional comparison assimilation. These predictions were not supported. Although the math/verbal DIBs manipulation was successful in 2 of the 3 studies, no significant dimensional comparison

contrast or assimilation effects were found. Implications for dimensional comparison theory and future directions are discussed.

DOMAIN INTERDEPENDENCE BELIEFS AS A MECHANISM FOR DIMENSIONAL COMPARISON: AN EXPERIMENTAL ANALYSIS

by

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CHAPTER I

INTRODUCTION

Sarah receives her final grades at the end of her first semester in college and is trying to decide if she wants to major in math. She already knew that she had a B in Calculus, which seemed fine, but she now discovers that she has an A in European Literature. Suddenly her B in Calculus seems inadequate and she begins to wonder if she is really a "math person." This example demonstrates the potential influence of *dimensional comparison*. Dimensional comparison occurs when people compare their standing in one domain (e.g., math) to their standing in another domain (e.g., verbal) and has been found to be a fundamental determinant of the self-concept, especially in academic settings where it has been widely researched (Marsh, 1986; Möller & Marsh, 2013).

In some contexts, dimensional comparison may result in a contrast effect: self-evaluations of the superior domain become inflated and self-evaluations of the inferior domain are deflated (e.g., Möller & Köller, 2001), as illustrated by the example above. In other contexts, however, dimensional comparison may result in an assimilation effect: self-evaluations of the superior domain become deflated and self-evaluations of the inferior domain are inflated (e.g., Jansen, Schroeders, Lüdtke, & Marsh, 2015). For example, at the end of his first semester in college, James knows that he received a B in Calculus and is disappointed, thinking that he must not be a "math person." However, he

then discovers that in Introductory Physics he received an A. He begins to think that he might actually be strong in math, but something about this particular Calculus class reduced his grade. Dimensional comparison to his better grade in physics increased his self-evaluations of his math ability, through an assimilation effect.

Although dimensional comparison studies have established the existence of both assimilation and contrast effects (e.g., Jansen et al., 2015; Marsh, Lüdtke, et al., 2015), it is unclear what mechanisms cause dimensional comparison assimilation or contrast to occur. Recently there have been repeated calls for clarification on the circumstances in which dimensional comparison is expected to result in assimilation versus contrast (e.g., Ehm, Lindberg, & Hasselhorn, 2014; Möller & Marsh, 2013). Understanding the direction of dimensional comparison effects is essential given that initial effects of dimensional comparison on the self-concept could have downstream consequences for decision-making (e.g., course or major selection), motivation, and subsequent performance (Marsh & Yeung, 1997; Schurtz, Pfost, Nagengast, & Artelt, 2014; Valentine, DuBois, & Cooper, 2004).

Drawing upon recent dimensional comparison research (e.g., Marsh et al., 2014; Möller, Streblow, & Pohlmann, 2006), as well as related work on social comparison (Mussweiler, 2003a), I propose that whether a dimensional comparison results in assimilation or contrast depends primarily on the comparer's belief about the interdependence of the domains being compared, their *domain interdependence belief* (DIB). If a person believes that the 2 domains are positively interdependent, then she believes that high standing in one domain is dependent on high standing in the other

domain. However, negative DIBs occur when a person believes that high standing in one domain is dependent on low standing in the other domain. I propose that holding positive DIBs for a domain pair predicts dimensional comparison assimilation when comparing the 2 domains, while holding negative DIBs for a domain pair predicts dimensional comparison contrast when comparing the 2 domains.

To test my predictions for DIBs as a primary mechanism of dimensional comparison, I conducted 3 experiments that each manipulated math/verbal DIBs to be positive or negative using different methods. Then, participants engaged in a dimensional comparison of math and verbal performance. I predicted that participants in the positive DIBs conditions would experience dimensional comparison assimilation when comparing math and verbal, while those in the negative DIBs conditions would experience contrast. To provide context for this dissertation, I first give a brief overview of dimensional comparison theory and research, highlighting the gaps that research on DIBs might fill. Then, I describe how DIBs can serve as a primary mechanism for dimensional comparison. Next, I describe prior work that may indirectly support DIBs, including moderators of dimensional comparison and a well-supported social comparison mechanism. Finally, I present the 3 experiments that tested whether DIBs are a primary mechanism of dimensional comparison.

Dimensional Comparison Research

Broadly, dimensional comparison can be defined as thinking about one's standing in a given domain relative to one's standing in another domain. Potential domains include a wide variety of characteristics including academic abilities, athletic skills, health-related

attributes, and personality traits. As described below, prior work on dimensional comparison has focused primarily on comparisons of academic skills such as math and verbal abilities. Nonetheless, the occurrence of dimensional comparisons with non-academic domains has also been supported, including attractiveness, honesty, physical fitness, and social skills (Möller & Husemann, 2006; Möller & Savyon, 2003). Thus, a mechanism of dimensional comparison should be able to address a broad range of domains beyond just academic skills to fully represent the nature and consequences of dimensional comparison effects.

Internal/external frame of reference model. Most dimensional comparison research is informed by the *internal/external frame of reference model* (I/E model; Marsh, 1986). The I/E model proposes that a student's self-concept in a particular academic subject is influenced by both an internal (within-person) frame of reference and an external (between-person) frame of reference. The internal frame of reference influences self-concepts when students use dimensional comparison to compare their performance in one domain to their performance in other domains. The external frame of reference influences self-concepts when students use social comparison to compare their performance to the performance of other people (e.g., classmates or schoolmates). The I/E model is typically tested using a path analysis of math and verbal achievement predicting math and verbal self-concept (e.g., Marsh, 1986). The external frame of reference is predicted to produce strong positive effects of math achievement on math self-concept and of verbal achievement on verbal self-concept. The internal frame of reference is predicted to produce moderate negative effects of math achievement on

verbal self-concept and of verbal achievement on math self-concept. Therefore, regarding dimensional comparison, the I/E model predicts that comparing math and verbal achievement will result in a dimensional comparison contrast effect on math and verbal self-concept.

Dozens of studies support the underlying predictions of the I/E model. Along these lines, a meta-analytic path-analysis of 69 studies showed large positive effects of math or verbal achievement (e.g., grades or standardized test results) on self-concepts in the same domain, supporting the effect of the external frame of reference and of social comparison (Möller, Pohlmann, Köller, & Marsh, 2009). The meta-analytic path-analysis also showed moderate negative effects of achievement on self-concept in the opposing domain, supporting the effect of the internal frame of reference and of dimensional comparison. Furthermore, support for the I/E model has been obtained in numerous regions across the globe, including every inhabited continent, which suggests that the model is cross-culturally valid (Chiu, 2008, 2012; Marsh, Abduljabbar, et al., 2015; Marsh & Hau, 2004). Finally, longitudinal studies have repeatedly measured math and verbal achievement as well as math and verbal self-concepts over a 2 to 4 year time period and have found that internal and external comparisons significantly predict changes in the self-concept over time (e.g., Marsh, 1990; Marsh & Yeung, 1998; Möller, Retelsdorf, Köller, & Marsh, 2011; Möller, Zimmermann, & Köller, 2014).

Dimensional comparison experiments. Although the large majority of studies on dimensional comparison have employed the correlational methodology of the I/E model, emerging experimental research provides evidence that dimensional comparisons

can have a causal effect on self-evaluations. Initial experiments provided participants with feedback about their performance in one domain and then observed whether this feedback influenced self-concepts in one or more other domains. Consistent with dimensional comparison theories, participants told that they performed below average on a math test evaluated their verbal ability more favorably than participants told that they performed above average on a math test (Möller & Köller, 2001, Study 1). Similarly, participants told that they performed below average on an intelligence test rated themselves as (marginally) more honest than participants told that they performed above average on an intelligence test, but this work was limited by low statistical power (Möller & Savyon, 2003). These findings on dimensional comparison are consistent with earlier studies on *compensatory self-inflation*, which found that threatening feedback in one domain leads people to evaluate themselves more favorably in other domains in order to retain a positive sense of self (Baumeister & Jones, 1978; Greenberg & Pyszczynski, 1985).

Other experiments have obtained dimensional comparison effects when participants were given more direct feedback highlighting differences in performance across domains. For example, participants evaluated their math ability more favorably when they were told that their performance on a math test was superior as opposed to inferior to their performance on a verbal test (Möller & Köller, 2001, Studies 2 & 3). Additionally, participants told that they performed average on a math test evaluated their math ability more favorably when they were also told that they performed below average (worse) as opposed to above average (better) on a verbal test (Pohlmann & Möller, 2009;

see also, Strickhouser & Zell, 2015). These dimensional comparison contrast effects have also been found when examining judgments of other people. Specifically, participants who were told that a student performed well in a verbal class evaluated that student's verbal ability more favorably when they were also told that the student performed poorly as opposed to well in a math class (Dickhäuser, 2005). Together, these experiments demonstrate that dimensional comparisons can cause contrast effects on self and social judgments.

Assimilation versus contrast. Typically, dimensional comparisons of math and verbal domains result in contrast, but dimensional comparisons of other domains sometimes yield weaker contrast effects or even assimilation effects. This pattern is demonstrated by several recent studies that expanded the I/E model to include the domain of verbal ability in a foreign language in addition to the more typical domains of math ability and native language verbal ability (Brunner et al., 2010; Marsh & Yeung, 2001; Marsh, Kong, & Hau, 2001; Marsh et al., 2014; Xu et al., 2013). The domain of foreign language verbal ability showed much weaker dimensional comparison contrast effects with native language verbal ability than with math ability. Other studies have investigated the I/E model with just math and science domains and found weak dimensional comparison contrast effects (Chiu, 2008, 2012; Marsh, Abduljabbar, et al., 2015). Still other studies have found no significant dimensional comparison contrast effects between math and biology (Nagy, Trautwein, Baumert, Köller, & Garrett, 2006), chemistry and biology (Dickhäuser, Reuter, & Hilling, 2005), or German and English (Faber, 2012).

Expanding further, several studies have included 4 or more domains in a very large version of the I/E model (Jansen et al., 2015; Marsh, Lüdtke, et al., 2015; Möller, Streblow, Pohlmann, & Köller, 2006; Sparfeldt, Schilling, Rost, & Thiel, 2006). Typically, these studies used at least German, English, physics and math, but some also included biology, chemistry, or history. The results of these large I/E model studies will be described in more detail later, but briefly, if the academic domains are clustered into a "verbal" block (e.g., English, German, and history) and a "math" block (e.g., math, physics, and chemistry), then domains in different blocks tended to show dimensional comparison contrast and domains in the same block tended not to significantly contrast and sometimes showed dimensional comparison assimilation. In sum, results of these multiple academic domain I/E model studies suggest that dimensional comparison contrast effects are strongest between math and verbal domains, while other academic domain combinations result in a weaker contrast effect, no effect, or even an assimilation effect.

Complementing the correlational I/E model studies demonstrating the existence of both contrast and assimilation effects in dimensional comparison, experimental studies of dimensional comparison have also found both contrast and assimilation effects. Most dimensional comparison experiments have investigated math and verbal domains and have yielded a strong dimensional comparison contrast effect (e.g., Pohlmann & Möller, 2009; Strickhouser & Zell, 2015). However, in some cases manipulated positive feedback in one domain can positively influence self-evaluations in other domains, indicative of a dimensional comparison assimilation effect. In one experiment demonstrating this

assimilation effect, Japanese participants told that they performed well on a creativity test rated themselves more favorably on several other traits (e.g., attractive, dependable, independent) compared to participants told that they performed poorly on the creativity test (Heine, Kitayama, & Lehman, 2001). In another study demonstrating assimilation, participants told that they scored high on a desirable and important personality trait rated themselves more favorably on other desired traits compared to participants told that they scored high on an undesirable and important personality trait (Eisenstadt, Leippe, & Rivers, 2002). These inconsistent findings in the literature call out for clarification on the circumstances in which dimensional comparisons yield assimilation versus contrast effects.

Domain Interdependence Beliefs

Dimensional comparison theories are currently unclear on why these comparisons sometimes result in an assimilation effect and other times a contrast effect on domain self-concepts (see Ehm et al., 2014; Möller & Marsh, 2013). Addressing this gap, I propose that *domain interdependence beliefs* (DIBs) may be a critical mechanism that underlies dimensional comparison effects. Domain interdependence beliefs involve whether people think high standing in one domain is positively dependent on, negatively dependent on, or independent of high standing in one or more other domains. Negative interdependence beliefs occur when people believe that high standing in one domain is dependent on low standing in another domain (e.g., high standing in math is dependent on low standing in verbal). Positive interdependence beliefs occur when people believe

that high standing in one domain is dependent on high standing in another domain (e.g., high standing in math is dependent on high standing in science).

A person's DIBs might be initially formed in a variety of ways. For example, students may develop domain independence beliefs regarding math and verbal domains from observation of their own performance, information they receive regarding general trends in people's performance, or widely-shared cultural stereotypes linking demographic groups to success and failure in different performance domains. Regardless of the source, I propose that the comparer's DIB for a pair of domains can be used to predict the outcome of a dimensional comparison between that pair of domains. If a person holds a negative DIB for the domain pair, then the dimensional comparison will result in a contrast effect where self-evaluation of the superior domain will be inflated and self-evaluation of the inferior domain deflated. If a person instead holds a positive DIB for the domain pair, then the dimensional comparison will result in an assimilation effect, where self-evaluations of the superior domain will be deflated and self-evaluations of the inferior domain inflated.

Related Research

At present, no research to my knowledge has systematically tested whether positive or negative DIBs cause dimensional comparison assimilation or contrast, respectively. However, several studies provide tentative support for the argument that DIBs are a dimensional comparison mechanism, including research on selective accessibility, math/verbal continuum studies, and work on negative interdependence of ability beliefs. I evaluate each of these potential sources of support for DIBs as a primary

mechanism of dimensional comparison while noting gaps that the present research aims to fill.

Selective accessibility. Social comparison occurs when people compare their own attributes, traits, and abilities to those of other people, such as their friends, family, co-workers, or neighbors (Festinger, 1954; Fiske, 2011; Suls & Wheeler, 2000). Like dimensional comparison, social comparison can result in either assimilation or contrast effects (Buunk, Collins, Taylor, VanYperen, & Dakof, 1990; Wheeler & Suls, 2005). Upward comparisons to someone who is superior to the self can lead to a contrast effect where people evaluate themselves more negatively or an assimilation effect where people evaluate themselves more positively. Similarly, downward comparisons to someone who is inferior to the self can lead to a contrast effect where people evaluate themselves more positively or an assimilation effect where people evaluate themselves more negatively.

The selective accessibility model (SAM; Mussweiler, 2003a, 2003b) argues that a broad assessment of perceived similarity between the comparison referent and the self—defined by shared category membership (e.g., gender, age, ethnicity) or situationally relevant characteristics (e.g., attitudes, dispositions)—determines whether social comparisons yield assimilation or contrast effects on self-judgments. Specifically, when people initially perceive themselves as broadly similar to a referent, additional information indicating similarity between the self and referent is selectively activated during the comparison process, ultimately resulting in an assimilation effect. Conversely, when people initially perceive themselves as broadly different from a comparison referent, additional information indicating dissimilarity between the self and referent is

selectively activated during the comparison process, ultimately resulting in a contrast effect. In sum, the SAM proposes that whether social comparisons result in assimilation or contrast effects depends on broad perceived similarity between the referent and the self.

Several studies support the argument that perceived similarity to the comparison referent determines whether social comparisons result in assimilation or contrast effects (see Mussweiler, 2007, 2009). In a typical SAM experiment, participants are primed to focus on differences or similarities using a procedural priming task, for instance, they might have to identify as many similarities or differences as they can between 2 images (e.g., Mussweiler, 2001). After priming, participants compare themselves to a referent and those primed to focus on dissimilarities tend to contrast their self-evaluations away from the referent, while those primed to focus on similarities tend to assimilate their self-evaluations toward the referent. Thus, whether a social comparison results in assimilation or contrast can depend on whether the comparer is initially focused on similarities or dissimilarities.

Just as perceived similarity between the comparison referent and the self may determine the direction of social comparison effects, I propose that the perceived interdependence of 2 domains may determine the direction of dimensional comparison effects. Positive interdependence beliefs may occur for domains that are judged to be highly similar in content or in the skills necessary for success (e.g., math and science), while negative interdependence beliefs may occur for domains that are judged to be highly dissimilar (e.g., math and verbal). Preliminary evidence supports the proposed

connection between perceived similarity of domains and dimensional comparison effects (Helm, Mueller-Kalthoff, Nagy, & Möller, 2016). German high school students who were primed to focus on similarities by listing as many similarities as they could between 2 school subjects (Study 1: math and German; Study 2a: math and physics; Study 2b: English and German) later reported self-concepts in the 2 subjects that were more similar than students primed to focus on dissimilarities.

Therefore, as would be predicted by the SAM, activating similarity beliefs may have resulted in a dimensional comparison assimilation effect where self-concepts were pulled toward each other, while activating dissimilarity beliefs may have resulted in a dimensional comparison contrast effect where self-concepts were pushed away from each other. However, one limitation of prior research linking the SAM to dimensional comparison (Helm et al., 2016) is that dimensional comparison was not manipulated in these studies but was inferred on the basis of similarities or differences in self-concept ratings. Thus, additional research is needed to explore whether manipulating the perceived similarity of the performance domains actually causes differences in dimensional comparison effects. Further, because selective accessibility research has largely focused on how perceived similarity explains social comparison effects, it remains unclear to what extent the perceived similarity of domains explains dimensional comparison effects.

Math/verbal continuum. Research on the associations between student self-concepts in various academic domains has suggested that academic domains can be organized on a continuum from more math-associated domains (e.g., math, physics) to

more verbal-associated domains (e.g., literature, history; Marsh, Byrne, & Shavelson, 1988). Recently, researchers have argued that this math/verbal continuum (M/V Continuum) can be used to predict the outcome of dimensional comparisons; specifically, domains far apart on the continuum are expected to contrast but domains that are near each other are expected to assimilate (see Marsh et al., 2014). Consistent with this theory, two studies conducted with German students in 7th to 10th grade found evidence for dimensional comparison contrast when examining math and verbal domains, which are far apart on the M/V continuum (Möller, Streblow, Pohlmann, & Köller, 2006; Sparfeldt et al., 2006). Furthermore, there was a dimensional comparison assimilation effect between math and physics, which are near each other on the M/V continuum, as well as German and English, which are also near each other on the M/V continuum. Other studies have tested the near/far predictions of the M/V continuum with a wider variety of domains (Jansen et al., 2015; Marsh, Lüdtke, et al., 2015). In each of these M/V continuum studies, domains far apart on the M/V continuum (e.g., math and verbal) reliably showed dimensional comparison contrast effects, domains that were separated by a smaller distance showed weaker contrast (e.g., math and history, math and biology), and domains close to each other on the M/V continuum tended to show assimilation effects (e.g., math and physics).

Together, these studies indicate that the location of academic domains along the M/V continuum determines whether such domains yield dimensional comparison assimilation or contrast. What remains unclear, however, is why domains that are near each other on the continuum yield assimilation while those far away yield contrast. I

propose that people hold negative interdependence beliefs for domains that are far apart on the continuum, such as math and verbal, but positive interdependence beliefs for domains that are close on the continuum, such as math and physics. Thus, differences in DIBs may explain variations in the direction dimensional comparison effects across the M/V continuum. Additionally, DIBs provide a more flexible model to assessing the similarity between domains and making predictions about the outcome of a dimensional comparison. There are a variety of approaches to evaluating similarity including geometric, featural, alignment, and transformational models (Goldstone & Son, 2012). The M/V continuum exclusively represents similarity between domains geometrically as the proximity of domains in a 1-dimensional space ranging from more math-like to more verbal-like. In contrast, DIBs rely on the individual comparer's perception of similarity, which may be based on whichever model of similarity the comparer finds most relevant for the domains. Although there is support for the dimensional comparison predictions of the M/V continuum from correlational studies, to my knowledge, there have been no experimental tests of the M/V continuum or DIBs.

Interdependence beliefs. One study has examined whether domain interdependence beliefs moderate dimensional comparison effects (Möller, Streblow, & Pohlmann, 2006). German high school students reported their negative interdependence of ability beliefs (NABs) for math and verbal domains across 6 items such as "I think that some people are talented in math whereas others are talented in verbal domains." As predicted by the I/E model, there was a negative association between math achievement and verbal self-concept as well as a negative association between verbal achievement and

math self-concept. However, these dimensional comparison contrast effects were significantly stronger among participants with higher NABs.

This study provides initial evidence suggesting that interdependence beliefs predict the strength of dimensional comparison effects between math and verbal domains. Nonetheless, because the study was correlational in design, it remains unclear whether negative interdependence beliefs cause dimensional comparison contrast. It is possible that regularly engaging in dimensional comparison contrast causes interdependence beliefs to become more negative or that there is a 3rd factor independently influencing both interdependence beliefs and dimensional comparison. Furthermore, the study focused exclusively on negative interdependence beliefs and thus it remains unclear whether positive interdependence beliefs result in dimensional comparison assimilation.

The Current Studies

Informed by prior research on social and dimensional comparisons, I proposed that DIBs are a primary mechanism of dimensional comparison and can be used to make specific predictions about when a dimensional comparison between any 2 domains should result in an assimilation effect versus a contrast effect. I predicted that positive DIBs would lead to a dimensional comparison assimilation effect, while negative DIBs would lead to a dimensional comparison contrast effect. Prior to these studies, there was no research that directly tested these predictions. There is suggestive evidence from a prior correlational study demonstrating that the strength of dimensional comparison contrast effects is moderated by negative interdependence beliefs (e.g., Möller, Streblow, & Pohlmann, 2006). However, experimental tests of whether differences in DIBs cause

dimensional comparison effects are essential to rule out alternative explanations for the relation between DIBs and dimensional comparison effects. Further, prior research has yet to test whether dimensional comparison assimilation effects are caused by positive interdependence beliefs.

Addressing these gaps in the literature, the current studies examined whether DIBs are a primary mechanism of dimensional comparison that can be used to predict when assimilation versus contrast will occur. I predicted that holding negative DIBs between 2 domains causes dimensional comparisons of those domains to result in contrast, while holding positive DIBs causes dimensional comparison assimilation. I tested this prediction by experimentally manipulating participants' math/verbal DIBs and then examining the resulting effect on their math/verbal dimensional comparisons. I conducted 3 separate experiments with the same general design, but each manipulated math/verbal DIBs using a different method. Participants' math/verbal DIBs were manipulated using either a simple statement, a bogus scientific article, or tables presenting bogus data. To assess dimensional comparison effects, participants took a verbal reasoning test, received manipulated feedback about their verbal performance, and reported their math self-concept.

I predicted that when participants are manipulated to have negative math/verbal DIBs they would display dimensional comparison contrast effects. Specifically, I predicted that in the negative math/verbal DIBs conditions, participants' math self-concept would be significantly higher when they are given below average verbal performance feedback than when they are given above average verbal performance

feedback. In addition, I predicted that when participants are manipulated to have positive math/verbal DIBs they would display dimensional comparison assimilation effects. Specifically, in the positive math/verbal DIBs conditions, participants' math self-concept would be significantly lower when they are given below average verbal performance feedback than when they are given above average verbal performance feedback. If my predictions are supported, these studies will contribute to the dimensional comparison literature by explaining why these comparisons sometimes result in assimilation effects, but other times result in contrast effects.

CHAPTER II

STUDY 1: SIMPLE STATEMENT MANIPULATION

In this first study directly testing whether DIBs are a primary mechanism of dimensional comparison, I manipulated participants' math/verbal DIBs to be positive or negative using a simple statement that math and verbal are positively or negatively related. Then, I provided false feedback that participants had performed above average or below average on a test of verbal reasoning skills and I had them report their math self-concept. I predicted that a dimensional comparison contrast effect would occur in the negative interdependence statement conditions and a dimensional comparison assimilation effect would occur in the positive interdependence statement conditions.

Pilot 1: Simple Statement Pilot Test

I conducted a pilot test to evaluate the viability of a simple statement manipulation. As opposed to manipulating DIBs for math and verbal, this pilot manipulated DIBs for novel domains (i.e., discrete thinking skills and active identification ability), under the expectation that doing so would yield larger effects because participants had no prior experience with these domains. Unless noted, all other methodological aspects were similar to those described below for Study 1.

Pilot 1 method. Eighty participants first completed a bogus 15-item multiple choice thinking skills test that supposedly assessed inductive thinking skills, semantic thinking skills, and discrete thinking skills. Although the questions had real answers, they

were assembled from a diverse array of other measures and did not actually assess anything in particular (e.g., “What comes next in this series: Seven, Ten, Eight, Eleven, Nine, Twelve” multiple choice options: “Seven”, “Ten”, “Twelve”, “Thirteen” and “If you achieve something meaningful to you, you feel” multiple choice options: “Interested”, “Calm”, “Proud”, “Sympathetic”).

After completing the test, participants received randomly assigned manipulated feedback that their discrete thinking skills performance was above average or below average. To manipulate their DIBs, participants then received randomly assigned simple statements indicating that discrete thinking skills are either positively interdependent or negatively interdependent with active identification ability. Specifically, participants were told “People who perform WELL on tests of Discrete Thinking tend to perform WELL (POORLY) on tests of Active Identification. People who perform POORLY on tests of Discrete Thinking tend to perform POORLY (WELL) on tests of Active Identification.” Following the manipulation, participants reported their self-concept for discrete thinking skills (Mean α = .74) and active identification ability (Mean α = .74) using 2 parallel scales. Four participants were excluded from analyses because they failed a manipulation check asking them to recall their discrete thinking feedback.

Pilot 1 results. A 2 (discrete thinking feedback: above average, below average) by 2 (DIBs information: negative, positive) ANOVA conducted on active identification self-concept yielded the predicted interaction, $F(1, 72) = 9.71$, $p = .003$, $\eta_p^2 = .12$ (see Figure 1). In the negative DIBs conditions, a planned contrast yielded a non-significant dimensional comparison contrast effect, $t(72) = 1.52$, $p = .13$, $d = 0.47$. Active

identification ability self-concept was non-significantly higher in the below average discrete thinking feedback condition (*M* = 6.06, *SD* = 1.06) than in the above average discrete thinking feedback condition (*M* = 5.50, *SD* = 1.31). However, in the positive DIBs conditions, a planned contrast yielded a significant dimensional comparison assimilation effect, $t(72) = -2.91$, $p = .005$, $d = -1.01$. Active identification ability self-concept was significantly lower in the below average discrete thinking feedback condition (*M* = 5.28, *SD* = 1.04) than in the above average discrete thinking feedback condition (*M* = 6.32, *SD* = 1.01).

A 2 (discrete thinking feedback: above average, below average) by 2 (DIBs information: negative, positive) ANOVA conducted on discrete thinking skills self-concept yielded a significant main effect of discrete thinking feedback, $F(1, 72) = 32.97$, $p < .001$, $\eta_p^2 = .28$. Discrete thinking skills self-concept was lower in the 2 below average discrete thinking feedback conditions (*M* = 5.35, *SD* = 1.15) than in the 2 above average discrete thinking feedback conditions (*M* = 6.67, *SD* = 1.02). There was no main effect of DIBs information, $F(1,72) = 0.03$, $p = .87$, $\eta_p^2 < .001$, and the interaction was not significant, $F(1, 72) = 1.28$, $p = .26$, $\eta_p^2 = .02$.

Pilot 1 discussion. In sum, this successful pilot test suggests that the simple statement manipulation might be effective for testing whether DIBs are a primary mechanism for dimensional comparison. However, because the pilot used novel domains, it is possible that the obtained results may not generalize to domains such as math and verbal, for which people likely have preexisting DIBs. Additionally, participants in the pilot were provided the simple statement manipulation after the performance feedback

and thus the strong effects of the simple statement may have been a result of demand characteristics. Study 1 partially addressed this concern by giving the simple statement manipulation before the performance feedback.

Study 1 Methods

Participants and design. Participants were 139 introductory psychology students who participated in exchange for course credit (61% female, 40% White, 37% Black, M_{age} = 20.03). Participants were randomly assigned to the cells of a 2 (simple statement manipulation: negative math/verbal DIBs, positive math/verbal DIBs) by 2 (verbal reasoning feedback: above average, below average) design. Participants were collected until there were at least 30 participants per group, as this would yield at least 80% power to detect the critical interaction effect assuming the effect size in this study is greater than η_p^2 = .06 (determined using G*Power). The effect size for the critical interaction in a pilot with a similar design was η_p^2 = .12 (see Pilot 1 reported above). However, the pilot used novel domains and a more transparent manipulation, so it was anticipated that the effect size might be smaller in this study. There were 31 participants excluded from the primary analyses for failing at least 1 of the manipulation checks or the suspicion probe, leaving a total of 108 participants.

Materials and procedure. All materials for Study 1 as well as subsequent studies reported in this dissertation are included in the Appendix. First, participants completed a 20-item multiple choice test of verbal reasoning skills (e.g., “In parts of the Arctic, the land grades into the landfast ice so _____ that you can walk off the coast and not know you are over the hidden sea.”; multiple choice responses: A. permanently, B.

*imperceptibly, C. irregularly, D. precariously, E. slightly). This test has been used in previous research and is sufficiently ambiguous to promote the believability of false performance feedback (see Strickhouser & Zell, 2015).

Then, to manipulate their math/verbal DIBs, participants were presented with a simple statement that math and verbal performance is either positively or negatively related. Specifically, participants were told "Last semester, 372 students at UNCG completed the Verbal Reasoning Test you completed today. In addition, they completed a Mathematical Reasoning Test you will not be taking. The results showed that: Students who performed WELL on the verbal test usually did WELL [POORLY] on the mathematical test. Students who performed POORLY on the verbal test usually did POORLY [WELL] on the mathematical test." A pilot test of a similar manipulation found that it significantly influenced dimensional comparison effects in the predicted direction (see Pilot 1 above). Additionally, to engage deeper processing and consolidate the information they just read, participants were asked whether they were surprised by the results of the previous study ("*I am surprised*" or "*I am not surprised*") and then were asked to write about why they were surprised or not surprised as an open text response.

To examine whether the participants' math/verbal DIBs after the simple statement manipulation mediated the effects of that manipulation, participants' math/verbal, DIBs were assessed using a 6-item scale (e.g., "I think that some people are talented in Math whereas others are talented in Verbal domains."). A pilot test found that this scale has adequate internal consistency (α = .86; N = 125).

Next, participants received randomly assigned feedback about their verbal reasoning skills performance. In the below average feedback conditions, the feedback stated "This semester, 259 students at UNCG have completed the Verbal Reasoning Skills Test. Your Verbal Reasoning Skills performance ranked better than 21% of these students. Your performance ranked BELOW AVERAGE." In the above average feedback conditions, the feedback stated "This semester, 259 students at UNCG have completed the Verbal Reasoning Skills Test. Your Verbal Reasoning Skills performance ranked better than 81% of these students. Your performance ranked ABOVE AVERAGE." Similar false feedback conditions have been used in previous studies (e.g., Strickhouser & Zell, 2015) and the effects were large enough to substantially influence participants' evaluations of their performance in the tested domain and rarely aroused suspicion that the feedback was false.

Finally, to assess the effect of the manipulations, participants used 3 parallel 6-item scales to report their self-concept for verbal, math, and science (e.g., "I think I could be quite good at using [domain]"). Science self-concept was assessed in order to confirm that the effect of manipulating math/verbal DIBs is unique to math self-concept and does not simply cause all domains to assimilate or contrast. Pilot testing found this type of self-concept scale to have adequate internal consistency when examining other domains (mean α = .74; see Pilot 1 above). Additionally, participants responded to 3 questions on how important they feel math is (e.g., "Mathematics is important to me personally") and 4 questions on their future interest in math (e.g., "I would like to work in a career involving mathematics.").

Manipulation checks and suspicion probe. At the end of the study, participants were asked to recall whether students who performed well on a previous mathematical reasoning skills test tended to do well or poorly on the verbal reasoning skills test. Also, they were asked to recall whether their verbal reasoning skills performance was above average, average, or below average. Additionally, a funnel debriefing was conducted to probe for suspicion that the feedback was false. Participants who did not answer both of the questions correctly or who failed the suspicion probe were excluded from the main analyses (31 participants excluded). Of those who were excluded, most (74%) failed only the simple statement manipulation check. Supplementary analyses found that including all participants did not lead to a different pattern of results, with one exception noted below.

Study 1 Results

Simple statement manipulation. A 2 (simple statement manipulation: negative math/verbal DIBs, positive math/verbal DIBs) by 2 (verbal reasoning feedback: above average, below average) ANOVA was conducted on math/verbal DIBs (see Figure 2). There was a significant main effect of the simple statement manipulation, $F(1, 104) = 16.67$, $p < .001$, $\eta_p^2 = .14$. Participants' math/verbal DIBs were significantly more positive in the positive math/verbal DIBs statement conditions ($M = 4.27$, $SD = 0.99$) than in the negative math/verbal DIBs statement conditions ($M = 3.50$, $SD = 0.98$). There was no significant main effect of verbal reasoning feedback, $F(1, 104) = 2.12$, $p = .15$, $\eta_p^2 = .02$, or interaction, $F(1, 104) = 2.31$, $p = .13$, $\eta_p^2 = .02$, confirming that feedback

conditions did not vary in math/verbal DIBs before the feedback manipulation was provided.

Dimensional comparison effects. A 2 (simple statement manipulation: negative math/verbal DIBs, positive math/verbal DIBs) by 2 (verbal reasoning feedback: above average, below average) ANOVA was conducted on math self-concept (see Figure 3). Contrary to predictions, there were no significant effects. The main effect of the simple statement manipulation, $F(1, 104) = 0.14$, $p = .71$, $\eta_p^2 = .001$, the main effect of verbal reasoning feedback, $F(1, 104) = 0.08$, $p = .78$, $\eta_p^2 = .001$, and their interaction, $F(1, 104) = 0.02$, $p = .89$, $\eta_p^2 < .001$, were all non-significant. Parallel analyses were conducted on participants' ratings of math importance, math interest, and science self-concept (see Figures 4-6) with similar non-significant results (*p's* > .11, η_p^2's < .03)

Mediation model. Whether the effect of the simple statement manipulation on math self-concept after dimensional comparison was mediated by participants' reports of their math/verbal DIBs after the simple statement manipulation was examined with a moderated mediation model. Verbal reasoning feedback condition was modeled as a moderator of both the direct and indirect effects of the simple statement manipulation on math self-concept (see Figure 8; Preacher, Rucker, & Hayes, 2007). The PROCESS macro for SPSS v2.16.3 (Hayes, 2013) was used to calculate 95% confidence intervals for the indirect effects with 10,000 bootstrapped samples.

As previously mentioned, the simple statement manipulation had a significant effect on math/verbal DIBs ($\beta = .37$, $t = 4.07$, $p < .001$). However, controlling for the simple statement and verbal feedback conditions, math/verbal DIBs did not significantly

predict math self-concept (β = .06, *t* = 0.57, *p* = .57) and the relation was not significantly moderated by verbal feedback condition (β = -.01, *t* = -0.11, *p* = .91). The indirect effect of the simple statement manipulation on math self-concept mediated by math/verbal DIBs did not significantly differ between the verbal feedback conditions (β = -.01, 95% CI [-.17, .15]), indicating that verbal feedback did not moderate the indirect effect. The indirect effect was not significant for either the below average verbal feedback condition (β = .03, 95% CI [-.11, .17]) or the above average verbal feedback condition (β = .02, 95% CI [-.08, .10]). Parallel moderated mediation analyses conducted with math importance and science self-concept as the outcome found similar non-significant results for the effect of math/verbal DIBs on the outcome (|β|'s < .08, *p's* > .45) and the indirect effect of the simple statement manipulation on the outcome mediated by math/verbal DIBs (|β|'s < .04, 95% CI's [<-.14, >.08]).

Students' ratings of math interest were not significantly predicted by math/verbal DIBs, controlling for the simple statement and verbal feedback conditions (β = .11, *t* = 1.08, *p* = .28) and the relation was not significantly moderated by verbal feedback condition (β = -.18, *t* = -1.68, *p* = .10). However, the indirect effect of the simple statement manipulation on math interest mediated by math/verbal DIBs significantly differed between the verbal feedback conditions (β = -.13, 95% CI [-.31, -.01]), indicating that verbal feedback moderated the indirect effect. The indirect effect was not significant for the above average verbal feedback condition (β = -.02, 95% CI [-.15, .08]), but was significant for the below average verbal feedback condition (β = .10, 95% CI [.02, .23]). For participants in the below average verbal feedback condition, receiving the positive

math/verbal DIBs simple statement resulted in more positive math/verbal DIBs, which predicted higher ratings of math interest compared to those who received the negative math/verbal DIBs simple statement and had more negative math/verbal DIBs.

However, the significant indirect effect on math interest in the below average verbal feedback condition was counteracted by a non-significant direct effect of the math/verbal DIBs simple statement on ratings of math interest that was in the opposite direction (β = -.25, t = 1.61, p = .11), resulting in a non-significant total effect in the below average verbal feedback condition (β = -.15, t = -0.75, p = .46). Furthermore, the significant indirect effect on math interest was not robust to the inclusion of participants who failed the manipulation check or suspicion probe. When including all participants, the indirect effect of the simple statement manipulation on math interest mediated by math/verbal DIBs did not significantly differ between the verbal feedback conditions (β = -.07, 95% CI [-.21, .03]), indicating that verbal feedback did not moderate the indirect effect. The indirect effect was not significant for the above average verbal feedback condition (β = -.04, 95% CI [-.15, .02]) or the below average verbal feedback condition (β = .03, 95% CI [-.04, .12]).

Social comparison effect. A 2 (simple statement manipulation: negative math/verbal DIBs, positive math/verbal DIBs) by 2 (verbal reasoning feedback: above average, below average) ANOVA was conducted on verbal self-concept (see Figure 7). Contrary to predictions, there was no significant main effect of verbal reasoning feedback $F(1, 104) = 2.62$, $p = .11$, $\eta_p^2 = .03$, or interaction, $F(1, 104) = 1.45$, $p = .23$, $\eta_p^2 = .01$, indicating that social comparison did not have a significant effect on verbal self-concept.

However, also contrary to predictions, there was a significant main effect of DIBs manipulation on verbal self-concept, $F(1, 104) = 4.47$, $p = .04$, $\eta_p^2 = .04$. Participants' verbal self-concept was significantly higher in the positive math/verbal DIBs statement conditions ($M = 6.07$, $SD = 1.51$) than in the negative math/verbal DIBs statement conditions ($M = 5.44$, $SD = 1.53$).

Study 1 Discussion

The predicted results were not obtained, failing to provide evidence that DIBs are a primary mechanism of dimensional comparison. Although the positive math/verbal DIBs simple statement did cause math/verbal DIBs to be more positive than the negative math/verbal DIBs simple statement, the simple statements and DIBs did not have any effect on dimensional comparisons. However, the simple statement manipulation used in this study has 2 potential limitations which may have led to the lack of dimensional comparison effects. First, the simple statement manipulation is composed of only a few brief sentences and provides no broader context or justification. Thus, even though the effect of the manipulation on math/verbal DIBs was significant, it may not have had a large enough effect to have a subsequent impact on dimensional comparison effects. To address this potential issue, participants in Study 2 will read a fake article that supposedly reviews extensive research supporting positive or negative math/verbal DIBs in a variety of different contexts, which might provide a more substantial manipulation of DIBs.

Second, it is possible that the simple statement is a transparent manipulation and that many participants guessed the purpose of the manipulation. This transparency could have led to demand characteristics that artificially inflated the effect on reported

math/verbal DIBs without actually impacting DIBs or dimensional comparison. Suspicion probes were included in this study to check for the presence of this potential issue, but it is possible that they were ineffective. The issue of demand characteristics is more directly addressed by Study 3 which uses a less transparent manipulation of DIBs.

CHAPTER III

STUDY 2: ARTICLE MANIPULATION

In this second study directly testing whether the DIBs are a primary mechanism of dimensional comparison, I manipulated participants' math/verbal DIBs with a bogus scientific article describing wide variety of research that either supported positive or negative math/verbal DIBs. It was expected that a detailed article providing broad justification and context for math/verbal positive or negative DIBs would provide a more generalizable manipulation than the simple statement used in Study 1 and might reflect the types of persuasive messages people receive about DIBs in everyday life (i.e., have higher mundane realism). I predicted that a dimensional comparison contrast effect would occur in the negative DIBs article conditions and a dimensional comparison assimilation effect would occur in the positive DIBs article conditions.

Pilot 2: Article Manipulation Pilot Test

I conducted a pilot study to examine whether the effect of the article manipulation is large enough to significantly affect math/verbal DIBs. Unless otherwise noted, all methodological aspects of the article manipulation in this pilot were identical to those described below for Study 2. However, this pilot did not include a verbal reasoning skills test or feedback, as the goal was simply to provide an initial test of the article manipulation.

Pilot 2 method. Seventy-seven participants were randomly assigned to read a bogus scientific article supporting the positive or negative interdependence of math and verbal ability. Next, in order to help disguise the purpose of the study and reduce demand characteristics, participants completed 20 filler questions from a personality inventory (Big Five Inventory; John & Srivastava, 1999). Finally, participants completed measures of math/verbal DIBs (mean α = .69) math/science DIBS (mean α = .59), and social studies/verbal DIBS (mean α = .13). Seven participants who failed to accurately recall the main point of the article they read were excluded.

Pilot 2 results. As predicted, participants' math/verbal DIBs were significantly more positive in the positive interdependence article condition (M = 4.69, SD = 0.78) than in the negative interdependence article condition (M = 3.52, SD = 0.89), $t(68)$ = 5.84, $p < .001$, d = 1.39 (see Figure 9). In contrast, as predicted, participants' math/science and verbal/social studies DIBs were unaffected by article condition. Specifically, math/science DIBs were similar in the positive interdependence article condition (M = 4.94, SD = 0.64) versus the negative interdependence article condition (M = 5.11, SD = 0.79), $t(68)$ = 1.00, p = .32, d = 0.24, and verbal/social studies DIBs were similar in the positive interdependence article condition (M = 4.70, SD = 0.50) versus the negative interdependence article condition (M = 4.73, SD = 0.50), $t(68)$ = 0.22, p = .83, d = 0.05.

Pilot 2 discussion. These pilot results demonstrate that the article manipulation successfully influenced math/verbal DIBs in the predicted manner. In addition, DIBs for other pairs of domains were unaffected by the article manipulation, demonstrating the

specificity of this manipulation. Thus, the article manipulation was expected to be useful in examining whether manipulating DIBs to be positive or negative causes dimensional comparison assimilation or contrast effects, respectively. If successful, this would provide evidence consistent with the argument that DIBs are a primary mechanism of dimensional comparison.

Study 2 Methods

As in Study 1, participants were 148 introductory psychology students who participated in exchange for course credit (72% female, 36% White, 35% Black, M_{age} = 19.28). Participants were randomly assigned to the cells of a 2 (article manipulation: negative math/verbal DIBs, positive math/verbal DIBs) by 2 (verbal reasoning feedback: above average, below average) design. There were 20 participants excluded from the primary analyses for failing at least 1 of the manipulation checks or the suspicion probe, leaving a total of 128 participants. Unless noted, all methodological aspects were parallel to Study 1.

First, participants completed a 20-item multiple choice test of verbal reasoning skills. Then, to manipulate their math/verbal DIBs, participants were randomly assigned to read one of two bogus scientific articles ostensibly from Psychology Today (see Appendix). Both articles reviewed work by multiple fictional researchers investigating the relation between performance in math and verbal domains. In one article, the research supports positive interdependence of math and verbal ability, explaining that people who excel in verbal domains also excel in math because learning mathematics is heavily dependent on oral and written language skills. In the other article, the research supports

negative interdependence of math and verbal ability, explaining that people who excel in verbal domains perform poorly in math because learning mathematics is entirely different from learning oral and written language skills. Participants were allotted 5 minutes to read their assigned article and were not able to advance until that time has elapsed. After reading the article, to engage deeper processing and consolidate the information they just read, participants were asked to summarize the main point of the article in 2-3 sentences, using their own words. In a pilot study, this article manipulation significantly influenced math/verbal DIBs in the predicted direction (see Pilot 2 reported above).

Next, participants' math/verbal DIBs were assessed. Then, participants received randomly assigned manipulated feedback that their verbal reasoning skills performance was above average or below average. After reviewing the feedback, participants used 3 parallel scales to report their self-concept for verbal, math, and science. Additionally, they responded to questions on how important they feel math is and on their future interest in math.

Manipulation check. At the end of this study, participants were asked to recall whether the article said that a person who performs well in verbal would be likely to perform well in math, perform poorly in math, or that verbal performance tells you nothing about math performance. Then as in Study 1, participants were asked to recall whether their own verbal reasoning skills performance was above average, average, or below average and a funnel debriefing for suspicion was conducted. Participants who did not answer both of the questions correctly or who failed the suspicion probe were excluded from the main analyses (20 participants excluded). Of those who were

excluded, most (70%) failed only the article manipulation check. Supplementary analyses found that including all participants did not lead to a different pattern of results.

Study 2 Results

Article manipulation. A 2 (article manipulation: negative math/verbal DIBs, positive math/verbal DIBs) by 2 (verbal reasoning feedback: above average, below average) ANOVA was conducted on math/verbal DIBs (see Figure 2). There was a significant main effect of the article manipulation, $F(1, 124) = 9.69$, $p = .003$, $\eta_p^2 = .07$. Participants' math/verbal DIBs were significantly more positive in the positive math/verbal DIBs statement conditions ($M = 4.09$, $SD = 1.05$) than in the negative math/verbal DIBs statement conditions ($M = 3.54$, $SD = 0.99$). There was no significant main effect of verbal reasoning feedback, $F(1, 124) = 0.001$, $p = .98$, $\eta_p^2 < .001$, or interaction, $F(1, 124) = 0.12$, $p = .73$, $\eta_p^2 < .001$, confirming that feedback conditions did not vary in math/verbal DIBs before the feedback manipulation was provided.

Dimensional comparison effects. A 2 (article manipulation: negative math/verbal DIBs, positive math/verbal DIBs) by 2 (verbal reasoning feedback: above average, below average) ANOVA was conducted on math self-concept (see Figure 3). Contrary to predictions, there were no significant effects. The main effect of the article manipulation, $F(1, 124) = 0.001$, $p = .97$, $\eta_p^2 < .001$, the main effect of verbal reasoning feedback, $F(1, 124) = 0.42$, $p = .52$, $\eta_p^2 = .003$, and their interaction, $F(1, 124) = 0.02$, $p = .88$, $\eta_p^2 < .001$, were all non-significant. Parallel analyses were conducted on participants' ratings of math importance and science self-concept (see Figures 4 & 5) with similar non-significant results (p's $> .23$, η_p^2's $< .02$).

However, the 2 by 2 ANOVA on math interest (see Figure 5) found a significant interaction $F(1, 124) = 5.27$, $p = .02$, $\eta_p^2 = .04$, with non-significant main effects of the article manipulation, $F(1, 124) = 0.19$, $p = .67$, $\eta_p^2 = .002$, and verbal feedback, $F(1, 124) = 0.18$, $p = .68$, $\eta_p^2 = .001$. Planned contrasts were used to decompose the significant interaction. In the negative DIBs conditions, the math interest of participants who received above average verbal feedback ($M = 1.85$, $SD = 1.23$) was non-significantly lower than those in the below average verbal feedback condition ($M = 2.63$, $SD = 1.87$), $t(124) = -1.92$, $p = .057$, $d = -0.49$, indicating a non-significant dimensional comparison contrast effect. While in the positive DIBs conditions, the math interest of participants who received above average verbal feedback ($M = 2.64$, $SD = 1.77$) was non-significantly higher than those in the below average verbal feedback condition ($M = 2.10$, $SD = 1.56$), $t(124) = 1.33$, $p = .19$, $d = 0.32$, indicating a non-significant dimensional comparison assimilation effect.

Mediation model. Whether the effect of the article manipulation on math self-concept after dimensional comparison was mediated by participants' reports of their math/verbal DIBs after the article manipulation was examined with a moderated mediation model. As in Study 1, verbal reasoning feedback condition was modeled as a moderator of both the direct and indirect effects of the article manipulation on math self-concept (see Figure 8). As previously mentioned, the article manipulation had a significant effect on math/verbal DIBs ($\beta = .26$, $t = 3.04$, $p = .003$). However, controlling for the article and verbal feedback conditions, math/verbal DIBs did not significantly predict math self-concept ($\beta = .04$, $t = 0.46$, $p = .65$) and the relation was not significantly

moderated by verbal feedback condition (β = -.11, t = -1.21, p = .23). The indirect effect of the article manipulation on math self-concept mediated by math/verbal DIBs did not significantly differ between the verbal feedback conditions (β = -.06, 95% CI [-.21, .05]), indicating that verbal feedback did not moderate the indirect effect. The indirect effect was not significant for either the below average verbal feedback condition (β = .04, 95% CI [-.03, .16]) or the above average verbal feedback condition (β = -.02, 95% CI [-.11, .06]). Parallel moderated mediation analyses conducted with math importance, math interest, and science self-concept as the outcome found similar non-significant results for the effect of math/verbal DIBs on the outcome ($|\beta|$'s < .22, *p's* > .16) and the indirect effect of the article manipulation on the outcome mediated by math/verbal DIBs ($|\beta|$'s < .11, 95% CI's [<-.02, >.04]).

Social comparison effect. A 2 (article manipulation: negative math/verbal DIBs, positive math/verbal DIBs) by 2 (verbal reasoning feedback: above average, below average) ANOVA was conducted on verbal self-concept (see Figure 7). As predicted, there was a significant main effect of verbal reasoning feedback, $F(1, 124) = 12.60$, $p < .001$, $\eta_p^2 = .09$. Participants' verbal self-concept was significantly higher in the above average verbal feedback conditions (M = 6.56, SD = 1.49) than in the below average verbal feedback conditions (M = 5.51, SD = 1.83). There was no significant main effect of the article manipulation, $F(1, 124) = 0.11$, $p = .74$, $\eta_p^2 < .001$ or interaction, $F(1, 124) = 0.28$, $p = .60$, $\eta_p^2 = .002$.

Study 2 Discussion

As in Study 1, most of the predicted results were not obtained for this study, failing to provide evidence that DIBs are a primary mechanism of dimensional comparison. Although the positive math/verbal DIBs article did cause math/verbal DIBs to be more positive than the negative math/verbal DIBs article, the article manipulation and DIBs did not result in a dimensional comparison effect on math self-concept or math importance. Unlike in Study 1, though, some dimensional comparison effects in the predicted directions were found for a secondary outcome of math interest. However, the effects of the positive and negative DIBs articles on math interest were not mediated by participants' reported math/verbal DIBs, so the results do not support the hypothesis that DIBs are a primary mechanism of dimensional comparison.

Compared to the simple statement manipulation used in Study 1, the article manipulation in Study 2 provides more justification and context supporting positive or negative math/verbal DIBs, which was expected to cause a larger effect than in Study 1. However, like the simple statement manipulation, this article manipulation may have been somewhat transparent and allowed participants to guess the purpose of the math/verbal manipulation. Thus, it is possible that demand characteristics artificially inflated the observed effect on math/verbal DIBs without actually impacting dimensional comparison. To address this potential issue, I used a less direct manipulation in Study 3.

CHAPTER IV

STUDY 3: TABLE MANIPULATION

In Study 3, I used a subtler manipulation of DIBs. Specifically, participants viewed tables depicting math and verbal scores of fictional students. The scores either reflected a positive or negative relation between math and verbal performance. This table manipulation did not make an explicit argument about what the participants should think, but instead allowed them to examine the data and draw their own conclusions. Thus, this manipulation was expected to be less reactive than that used in Studies 1 and 2. I predicted that a dimensional comparison contrast effect would occur in the negative interdependence table conditions and a dimensional comparison assimilation effect would occur in the positive interdependence table conditions.

Pilot 3: Table Manipulation Pilot Test

I conducted a pilot study to examine whether the effect of the table manipulation is large enough to significantly affect math/verbal DIBs. Unless otherwise noted, all methodological aspects of the table manipulation in this pilot were identical to those described below for Study 3. However, this pilot did not include a verbal reasoning skills test or feedback, as the goal was simply to provide an initial test of the table manipulation.

Pilot 3 method. Participants were 40 workers (38% females, M_{age} = 33.23, 15% African-American, 68% Caucasian) recruited online from Amazon.com's Mechanical

Turk (MTurk), who were paid $1.00 for participation in this 8-10 minute study. Participants were randomly assigned to receive a set of tables containing manipulated scores on math and verbal tests for 24 students. Participants then answered a series of 16 multiple choice questions requiring them to engage with and process the content of the tables. As a filler task, participants answered 4 items on their general beliefs about math and verbal ("If they just tried harder, all students could score well on Math.", "Students who score poorly on Verbal would benefit from extra tutoring.", "I am confident that I could score well on Math if I tried hard.", "If I scored poorly on Verbal, I believe that extra tutoring would help me."). Finally, participants completed a 6-item math/verbal DIBs scale (α = .78, .86).

The 16 questions on the content in the tables were used as a manipulation check. Of the 40 participants, 5 scored lower than 80% and are excluded from the main analyses for failing the manipulation check. The cutoff was chosen empirically, as 80% correct was the main breakpoint in the distribution. That is, at 80% correct the distribution of scores displays a sharp angle instead of a smooth curve, suggesting a qualitative difference between the participants who scored above and below 80% (see Figure 10). Follow-up analyses without any exclusions are also provided, as the results differ slightly.

Pilot 3 results. As predicted, participants' math/verbal DIBs were significantly more positive in the positive interdependence table condition (M = 5.06, SD = 1.08) than in the negative interdependence table condition (M = 4.07, SD = 1.11), $t(33) = 2.66$, p = .01, d = 0.99 (see Figure 11). However, when participants who failed the manipulation

check were not excluded, math/verbal DIBs were only marginally more positive in the positive interdependence table condition (M = 4.76, SD = 1.06) than in the negative interdependence table condition (M = 4.03, SD = 1.24), $t(38) = 2.01$, $p = .052$, $d = 0.63$.

Pilot 3 discussion. These results demonstrate that the table manipulation successfully influenced math/verbal DIBs to be more positive or negative. Thus, the table manipulation was expected to be useful in examining whether manipulating DIBs to be positive or negative causes dimensional comparison assimilation or contrast effects respectively. If successful, this would provide evidence consistent with the argument that DIBs are a primary mechanism of dimensional comparison.

Study 3 Methods

As in Studies 1 and 2 participants were 151 introductory psychology students who participated in exchange for course credit (74% female, 40% White, 31% Black, M_{age} = 18.82). Participants were randomly assigned to the cells of a 2 (table manipulation: negative math/verbal DIBs, positive math/verbal DIBs) by 2 (verbal reasoning feedback: above average, below average) design. There were 17 participants excluded from the primary analyses for failing the manipulation check or suspicion probe or for answering less than 80% of the tables questions correctly, leaving a total of 134 participants. Unless noted, all methodological aspects were parallel to Studies 1 and 2.

First participants completed a 20-item multiple choice test of verbal reasoning skills. Then, to manipulate their math/verbal DIBs, participants were randomly assigned to receive one of two sets of tables containing bogus scores on math and verbal tests for 24 students, simply labeled Student A through Student X (see Appendix). In the positive

interdependence condition, the math and verbal scores showed a strong positive correlation; students with high math scores tended to have high verbal scores while students with low math scores tended to have low verbal scores. In the negative interdependence condition math and verbal scores showed a strong negative correlation; students with high math scores tended to have low verbal scores while students with low math scores tended to have high verbal scores.

Participants then answered 16 multiple choice questions requiring them to engage with and process the content of the tables. Participants were told that these questions were designed to assess their ability to accurately interpret information presented in table format. The questions ranged from simple table reading (e.g., "In Table 1, which student scored highest on Math?") to questions requiring them to consider the relation between math and verbal scores (e.g., "Across the 3 tables, _____ of the students who scored above 600 on Math also scored above 600 on Verbal.", multiple choice options: "More than half", Exactly half", "Less than half"). Participants who saw that most of the students who performed well in math also performed well in verbal were expected to adopt positive math/verbal DIBs, while participants who saw that most of the students who performed well in math also performed poorly in verbal were expected to adopt negative math/verbal DIBs

Next participants' math/verbal DIBs were assessed. Then, participants received randomly assigned manipulated feedback that their verbal reasoning skills performance was above average or below average. After reviewing the feedback, participants used 3 parallel scales to report their self-concept for verbal, math, and science. Additionally,

they responded to questions on how important they feel math is and on their future interest in math.

Manipulation check. The 16 questions on the content in the tables were used as a manipulation check. Participants needed to score at least an 80% to pass the table manipulation check. The cutoff was chosen empirically based on pilot test showing that answering 80% correct was a main breakpoint in the distribution (see Pilot 3 reported above). Also, identical to Studies 1 and 2, at the end of this study, participants were asked to recall whether their own verbal reasoning skills performance was above average, average, or below average and a funnel debriefing for suspicion was conducted. Participants who did not pass both of these manipulation checks or who failed the suspicion probe were excluded from the main analyses (17 Excluded). Supplementary analyses found that including all participants did not lead to a different pattern of results.

Study 3 Results

Table manipulation. A 2 (table manipulation: negative math/verbal DIBs, positive math/verbal DIBs) by 2 (verbal reasoning feedback: above average, below average) ANOVA was conducted on math/verbal DIBs (see Figure 2). There was no significant main effect of verbal reasoning feedback, $F(1, 130) = 0.71$, $p = .40$, $\eta_p^2 = .01$, or interaction, $F(1, 130) = 0.83$, $p = .37$, $\eta_p^2 = .01$, confirming that feedback conditions did not vary in math/verbal DIBs before the feedback manipulation was provided. However, the main effect of the table manipulation was not significant, $F(1, 130) = 1.40$, $p = .24$, $\eta_p^2 = .01$, indicating that the tables were not an effective means of manipulating math/verbal DIBs.

Dimensional comparison effects. A 2 (table manipulation: negative math/verbal DIBs, positive math/verbal DIBs) by 2 (verbal reasoning feedback: above average, below average) ANOVA was conducted on math self-concept (see Figure 3). Contrary to predictions, there were no significant effects. The main effect of the table manipulation, $F(1, 130) = 0.10$, $p = .75$, $\eta_p^2 < .001$, the main effect of verbal reasoning feedback, $F(1, 130) = 0.94$, $p = .33$, $\eta_p^2 = .01$, and their interaction, $F(1, 130) = 1.24$, $p = .27$, $\eta_p^2 = .01$, were all non-significant. Parallel analyses were conducted on participants' ratings of math importance, math interest, and science self-concept (see Figures 4-6) with similar non-significant results (*p's* > .25, η_p^2's < .01).

Mediation model. Whether the effect of the table manipulation on math self-concept after dimensional comparison was mediated by participants' reports of their math/verbal DIBs after the table manipulation was examined with a moderated mediation model. As in Studies 1 and 2, verbal reasoning feedback condition was modeled as a moderator of both the direct and indirect effects of the table manipulation on math self-concept (see Figure 8). As previously mentioned, the table manipulation did not have a significant effect on math/verbal DIBs ($\beta = .10$, $t = 1.20$, $p = .23$). Furthermore, controlling for the table and verbal feedback conditions, math/verbal DIBs did not significantly predict math self-concept ($\beta = .13$, $t = 1.37$, $p = .14$) and the relation was not significantly moderated by verbal feedback condition ($\beta = -.17$, $t = -1.94$, $p = .054$). The indirect effect of the table manipulation on math self-concept mediated by math/verbal DIBs did not significantly differ between the verbal feedback conditions ($\beta = -.03$, 95% CI [-.15, .01]), indicating that verbal feedback did not moderate the indirect effect. The

indirect effect was not significant for either the below average verbal feedback condition (β = .03, 95% CI [-.01, .11]) or the above average verbal feedback condition (β = -.004, 95% CI [-.06, .02]). Parallel moderated mediation analyses conducted with math importance, math interest, and science self-concept as the outcome found similar non-significant results for the effect of math/verbal DIBs on the outcome (|β|'s < .14=5, *p's* > .10.) and the indirect effect of the table manipulation on the outcome mediated by math/verbal DIBs (|β|'s < .03, 95% CI's [<-.01, >.01]).

Social comparison effect. A 2 (table manipulation: negative math/verbal DIBs, positive math/verbal DIBs) by 2 (verbal reasoning feedback: above average, below average) ANOVA was conducted on verbal self-concept (see Figure 7). Contrary to predictions, there was no significant main effect of verbal reasoning feedback, $F(1, 130) = 2.08$, $p = .15$, $\eta_p^2 = .02$, or interaction, $F(1, 130) = 0.001$, $p = .97$, $\eta_p^2 < .001$, indicating that social comparison did not have a significant effect on verbal self-concept. Also, there was also no significant main effect of the table manipulation, $F(1, 130) = 3.50$, $p = .06$, $\eta_p^2 = .03$.

Study 3 Discussion

A major advantage of the table manipulation used in Study 3 is that it is less transparent than the simple statement manipulation used in Study 1 and the article manipulation used in Study 2. Instead of directly telling the participants what to think about math/verbal DIBs, they were allowed to draw their own conclusions based on manipulated data. This was expected to make it more difficult for participants to guess the purpose of the DIBs manipulation and to reduce potential demand characteristics.

However, the inherent limitation of this less direct design is that participants may not always see the relation between math and verbal domains displayed in the tables, thus their math/verbal DIBs may not be influenced. Consequently, in this study the positive math/verbal DIBs table and questions did not cause math/verbal DIBs to be more positive than the negative math/verbal DIBs table. Furthermore, no significant dimensional comparison effects were observed in either the positive or negative table conditions.

CHAPTER V

GENERAL DISCUSSION

The circumstances in which dimensional comparison is expected to result in assimilation versus contrast are unclear. In these studies, I tested whether DIBs—people's beliefs about the interdependence of abilities in different domains—are a primary mechanism for dimensional comparison that can be used to predict when assimilation versus contrast will occur. In 3 parallel studies, participants completed a verbal test, experienced a manipulation of their math/verbal DIBs, received false feedback on their verbal performance, and reported their math self-concept. In Study 1, math/verbal DIBs were manipulated with a simple statement that math and verbal are positively or negatively related. In Study 2, math/verbal DIBs were manipulated with a bogus scientific article describing a wide variety of research that supported either positive or negative math/verbal DIBs. In Study 3, math/verbal DIBs were manipulated with data tables depicting math and verbal scores of fictional students. The scores in the tables reflected either a positive or negative relation between math and verbal performance.

Contrary to my predictions, manipulating DIBs to be negative did not lead to dimensional comparison contrast effects. In the negative math/verbal DIBs conditions, participants' math self-concept was not higher when they were given below average verbal performance feedback than when they were given above average verbal performance feedback. Furthermore, contrary to my predictions, manipulating DIBs to be

positive did not lead to dimensional comparison assimilation effects. In the positive math/verbal DIBs conditions, participants' math self-concept was not lower when they were given below average verbal performance feedback than when they were given above average verbal performance feedback. Thus, these studies did not provide evidence that DIBs are a primary mechanism for dimensional comparison.

However, although the primary predictions were not supported, some supplemental findings were significant. In Studies 1 and 2, which used the simple statement and article manipulation respectively, the math/verbal DIBs manipulations had a significant effect on participants' self-reported math/verbal DIBs. As predicted, the positive DIBs manipulations resulted in significantly more positive DIBs compared to the negative DIBs manipulations. Thus, those 2 DIBs manipulations appear to have been effective. Additionally, in Study 2 the predicted effect of manipulating DIBs on dimensional comparison effects was tentatively observed for the secondary outcome of math interest. The dimensional comparison effect of verbal feedback on math interest was significantly moderated by the math/verbal DIBs such that there was a non-significant assimilation effect in the positive DIBs conditions and a non-significant contrast effect in the negative DIBs conditions. Thus, it is possible that a specific combination of DIBs manipulation and outcome variable is required to observe the predicted effects.

Potential Explanations and Future Directions

The lack of significant results supporting the proposed DIBs processes underlying dimensional comparisons may have occurred for at least 4 reasons. First, although the

simple statement manipulation in Study 1 and the article manipulation in Study 2 appeared to be effective in altering participants' DIBs, it is possible that the math/verbal DIBs participants reported did not truly reflect their belief about the interdependence of math and verbal ability. Both the simple statement and article manipulations were relatively transparent manipulations and, even though very few participants reported any suspicions, they may have been influenced to some degree by demand characteristics to report DIBs in line with those presented in the manipulation. The lack of a significant effect for the more subtle table manipulation used in Study 3 might further indicate that the effects of the more transparent manipulations are not genuine. However, it is also possible that the table manipulation was too subtle, and most participants never became aware of the math/verbal relations indicated by the tables that they were shown. Future research is needed to identify other possible manipulations that would not be subject to demand characteristics, but might have a significant effect on DIBs.

Second, it is possible that the effect of the DIBs manipulations on participants' reported math/verbal DIBs did accurately reflect their DIBs, but the effect was not large enough to influence subsequent dimensional comparison effects. Even though the effect of the simple statement manipulation in Study 1 and the article manipulation in Study 2 on math/verbal DIBs was significant, a manipulation with a larger effect size might be required to influence dimensional comparison effects. Math/verbal DIBs may be strongly held beliefs and somewhat resistant to change. Instead of a one-shot manipulation lasting only a few minutes, an intensive intervention spread over several weeks may be required to achieve the necessary effect size. Future research might investigate how malleable

DIBs are and what kind of intervention would be required to alter DIBs substantially enough to impact dimensional comparison effects.

Third, it is possible that the effect of the DIBs manipulation on DIBs was sufficiently large, but there was no subsequent effect of the DIBs manipulation on dimension comparison because the feedback manipulation did not induce participants to engage in a dimensional comparison. Similar feedback manipulations have been used in multiple previous studies (e.g., Pohlmann & Möller, 2009; Strickhouser & Zell, 2015) and successfully resulted in dimensional comparison effects, but in the present studies no dimensional comparison effects were obtained. Perhaps the additional cognitive load of the DIBs manipulation reduced the participants' ability to process the more complex dimensional comparison information. Future research is needed to explore how working memory capacity and cognitive load might play a role in dimensional comparison processes.

Fourth, it is possible that DIBs simply are not a central mechanism that determines the direction and magnitude of dimensional comparison effects. Prior empirical evidence in support of DIBs has all been correlational in design (e.g., Jansen et al., 2015; Marsh, Lüdtke, et al., 2015; Möller, Streblow, & Pohlmann, 2006) and, therefore, could not directly indicate whether differences in DIBs actually caused differences in dimensional comparison effects. There are at least 2 alternative explanations for the correlations obtained in previous studies. 1) Perhaps the causal direction is reversed and frequently engaging in dimensional comparison contrast between 2 domains causes negative DIBs between those domains to develop, while

frequent assimilation causes positive DIBs to develop. 2) An uncontrolled confounding variable caused some participants to form more negative DIBs and also independently caused them to be more likely to engage in dimensional comparison contrasts. These studies are the first to examine whether the experimental manipulation of DIBs can cause dimensional comparison effects to change and this initial evidence does not support the causal influence of DIBs on dimensional comparison. However, it is possible that future research investigating this issue will produce different results. Additional experiments utilizing a variety of different designs and measures are needed before any firm conclusions about the effect of DIBs can be reached.

Conclusions

There are a wide variety of possible explanations for why the DIBs manipulations used in these studies did not influence dimensional comparison effects. Therefore, there are no definite implications of this research for dimensional comparison theory other than the clear need for further investigation of dimensional comparison. For instance, research is needed to explore the effectiveness of DIBs manipulations, the cognitive requirements of dimensional comparison, and whether the results found in these studies can be replicated with different measures and designs. However, assuming the null results indicate that DIBs are in fact not a primary mechanism underlying dimensional comparison effects, then this research would imply that there must be some other mechanism. The present research on DIBs drew inspiration from the SAM mechanism of perceived similarity for social comparison (e.g., Mussweiler, 2003a, 2003b), but perhaps dimensional comparison operates in a substantially different manner than social

comparisons. It is even possible that prior research on the I/E model (Marsh, 1986) that combines social and dimension comparison is misguided, if they are not compatible types of comparison. Nevertheless, any such implications for dimensional comparison theory are premature at the moment, as the null results in these studies could have many other explanations.

In closing, the present research does not support the hypothesis that DIBs are a primary mechanism underlying dimensional comparison. Although some of the DIBs manipulations appeared to be effective in influencing DIBs, my predictions that positive DIBs would cause dimensional comparison assimilation effects and negative DIBs would cause dimensional comparison in contrast effects were not supported. Therefore, recent calls for clarification on the circumstances in which dimensional comparisons result in assimilation versus contrast (e.g., Ehm et al., 2014) remain unanswered. Additional research is needed to examine the effectiveness of DIBs manipulations, the validity of DIBs measures, and the causal influence of DIBs on dimensional comparison outcomes.

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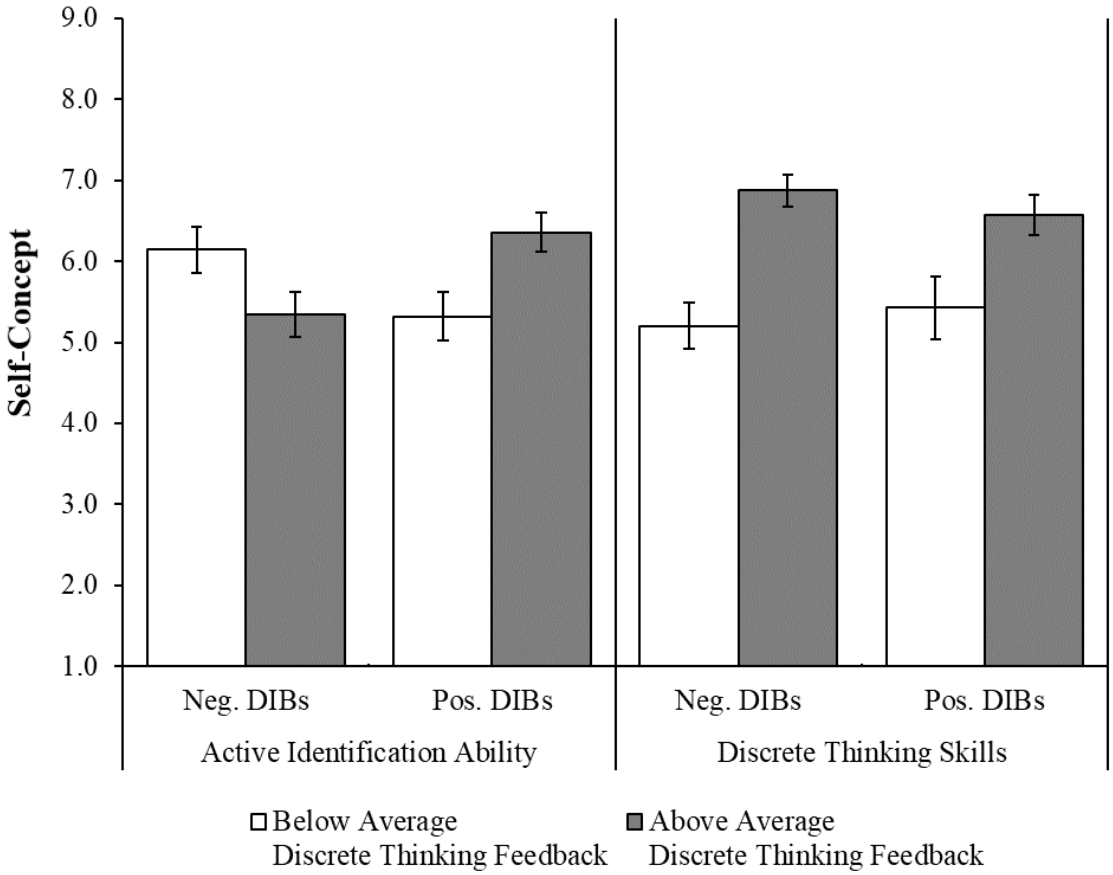
APPENDIX A

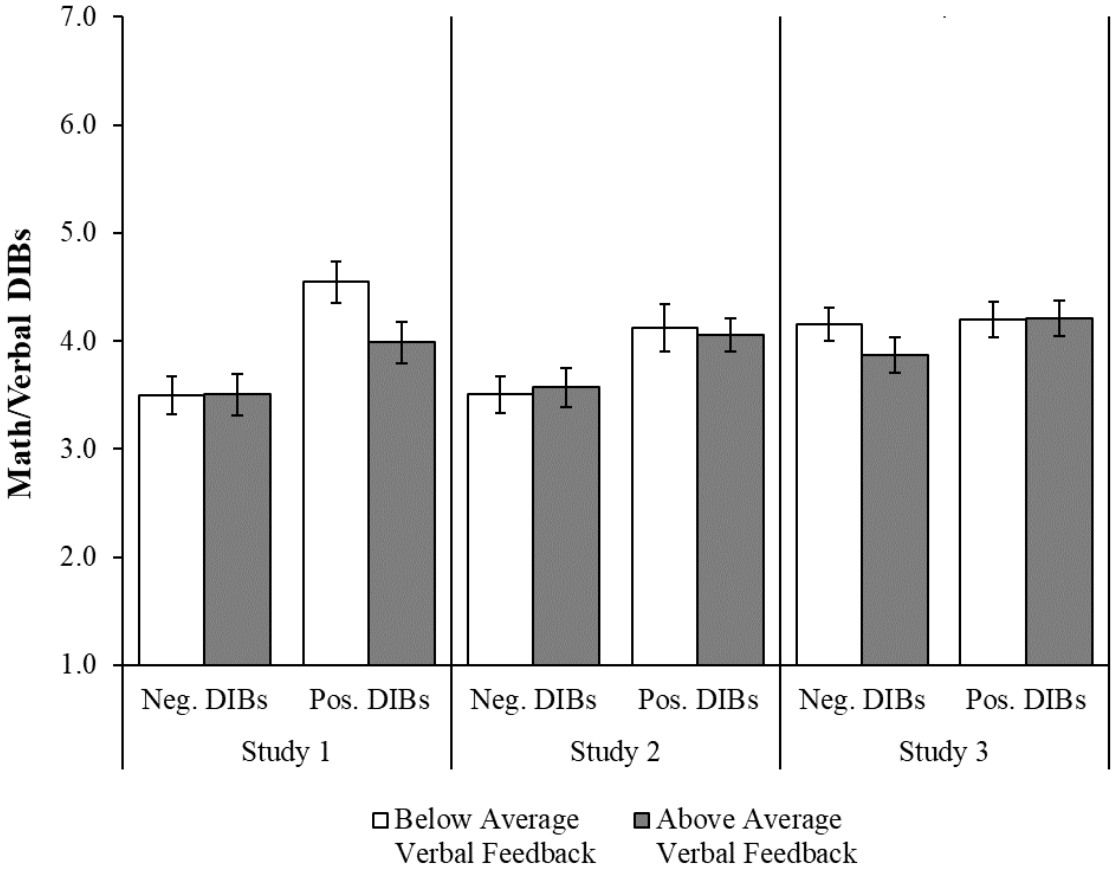
FIGURES

Figure 1. Pilot 1 Effects on Self-Concepts



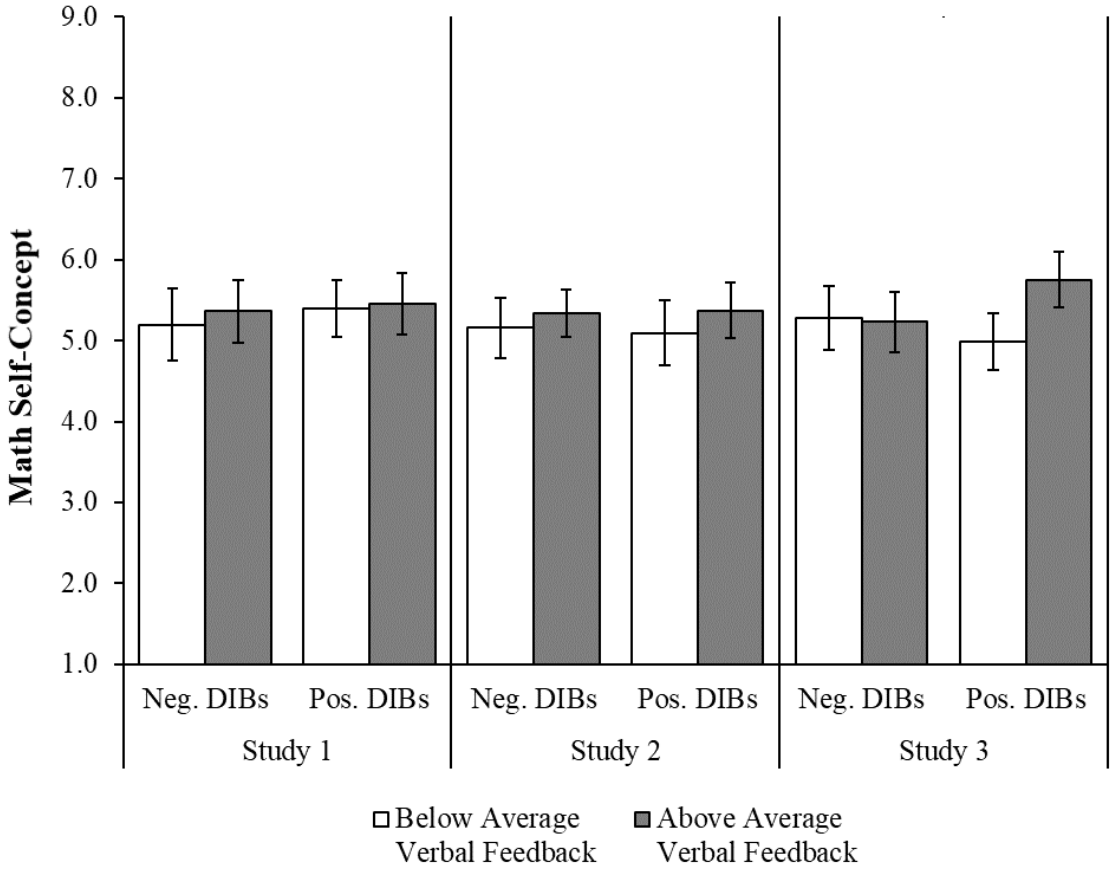
Note. For Pilot 1, the effect of the math/verbal DIBs manipulation and verbal feedback conditions on active identification ability and discrete thinking skills self-concepts. Error bars are +/- 1 standard error of the mean.

Figure 2. Effects on Math/Verbal DIBs



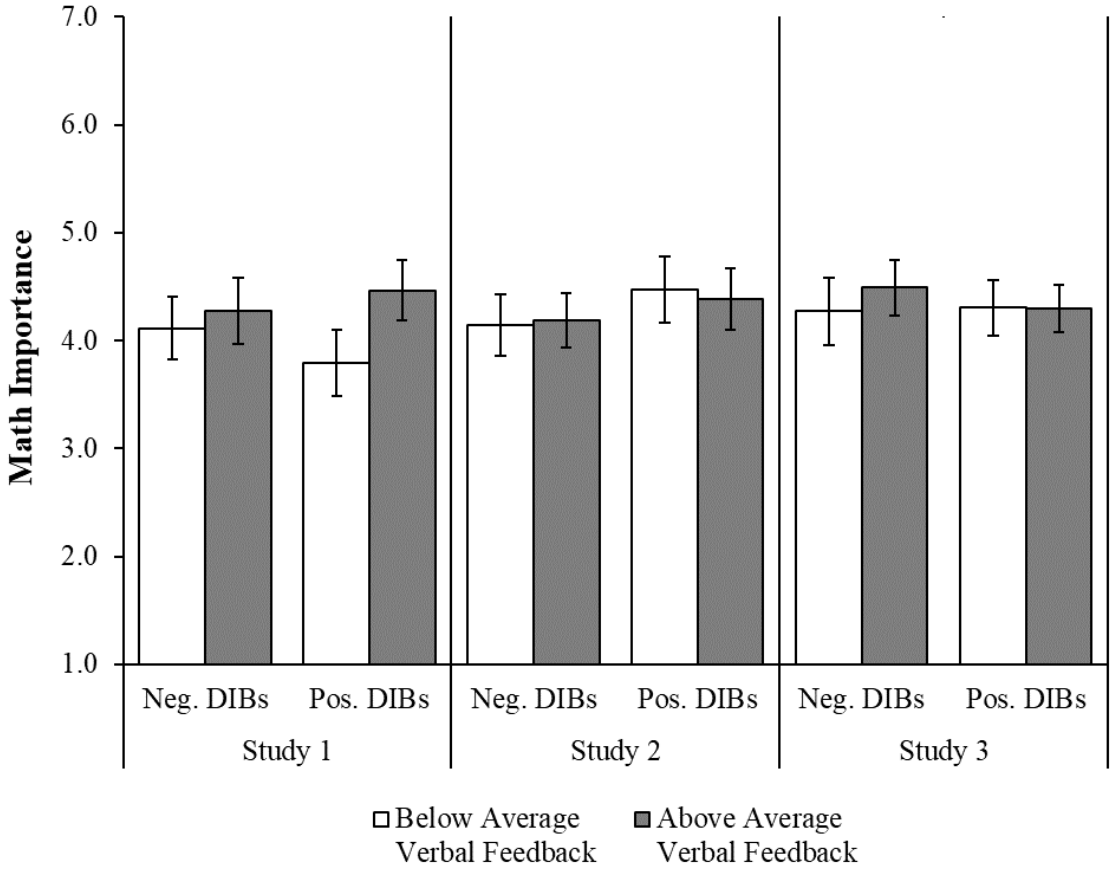
Note. For Studies 1-3, the effect of the math/verbal DIBs manipulation and verbal feedback conditions on math/verbal DIBs. Error bars are +/- 1 standard error of the mean.

Figure 3. Effects on Math Self-Concept



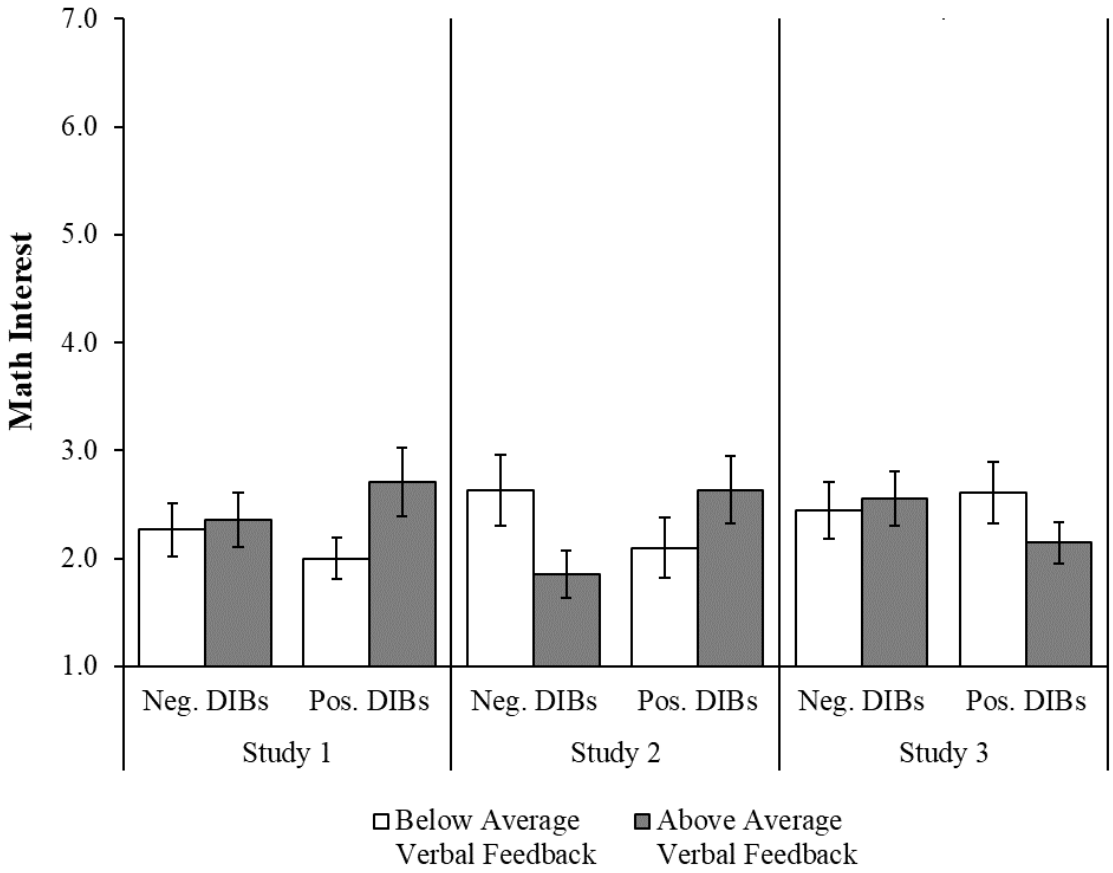
Note. For Studies 1-3, the effect of the math/verbal DIBs manipulation and verbal feedback conditions on math self-concept. Error bars are +/- 1 standard error of the mean.

Figure 4. Effects on Math Importance



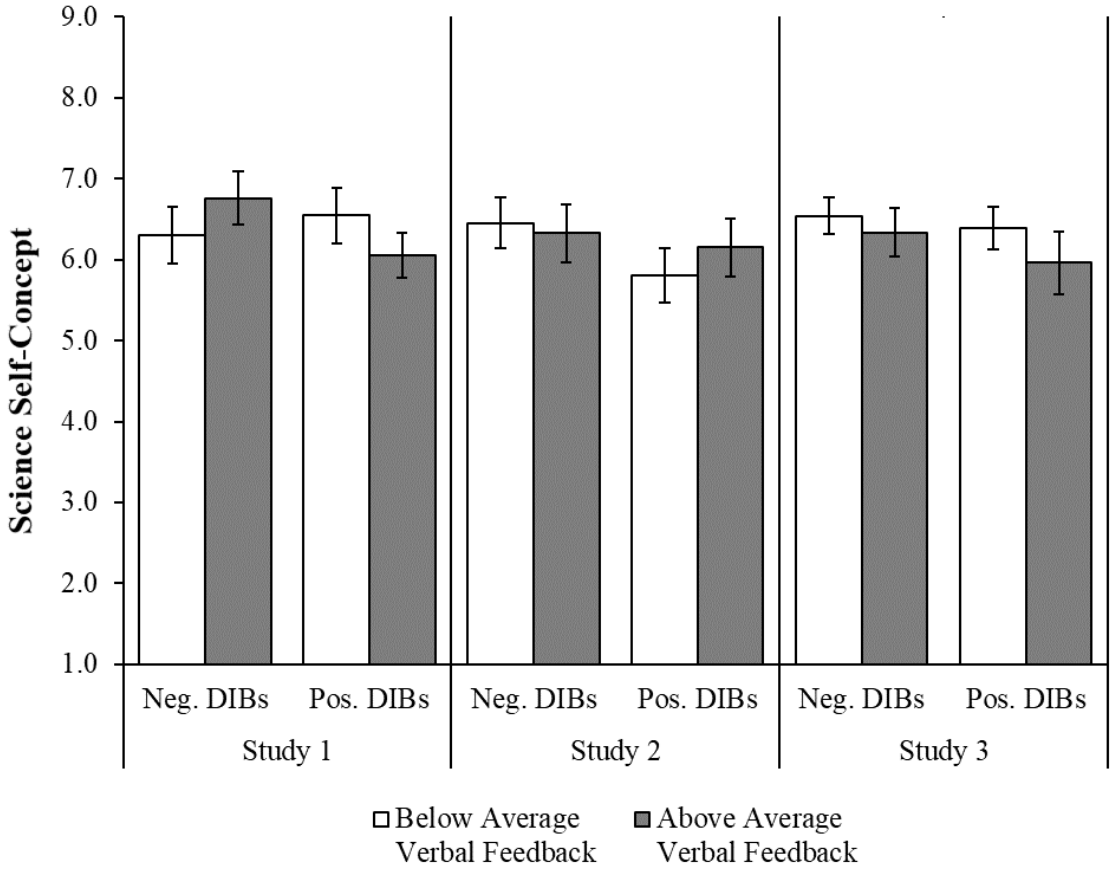
Note. For Studies 1-3, the effect of the math/verbal DIBs manipulation and verbal feedback conditions on math importance. Error bars are +/- 1 standard error of the mean.

Figure 5. Effects on Math Interest



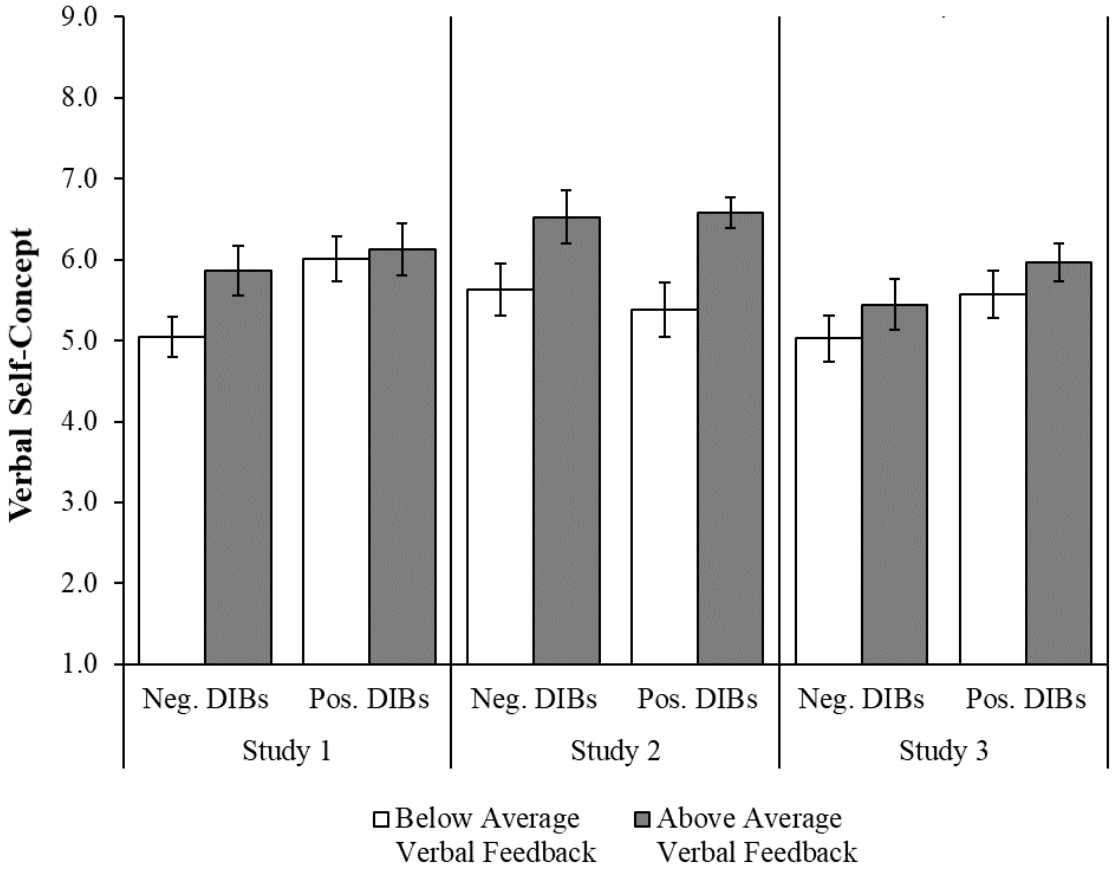
Note.. For Studies 1-3, the effect of the math/verbal DIBs manipulation and verbal feedback conditions on math interest. Error bars are +/- 1 standard error of the mean.

Figure 6. Effects on Science Self-Concept



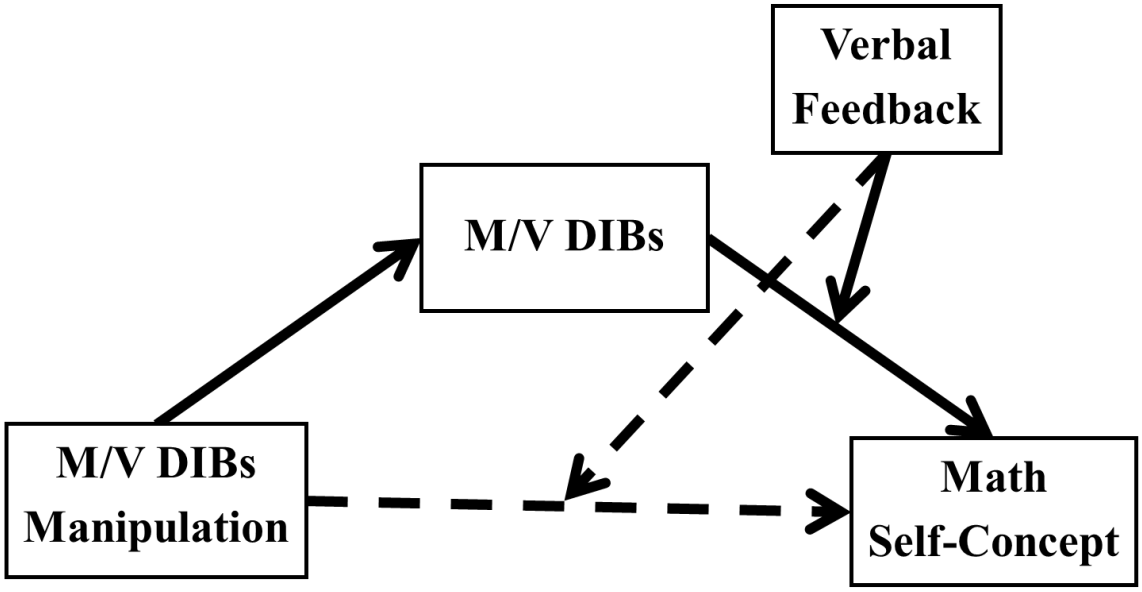
Note. For Studies 1-3, the effect of the math/verbal DIBs manipulation and verbal feedback conditions on science self-concept. Error bars are +/- 1 standard error of the mean.

Figure 7. Effects on Verbal Self-Concept



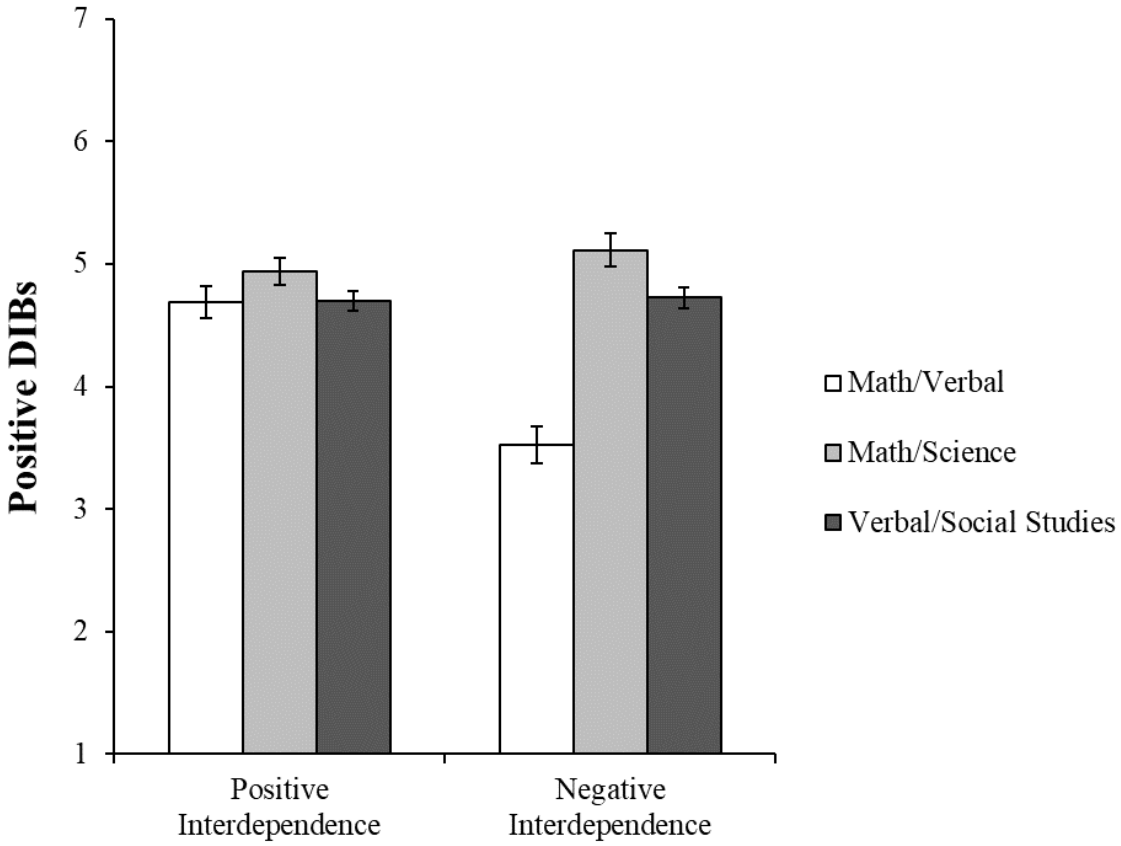
Note. For Studies 1-3, the effect of the math/verbal DIBs manipulation and verbal feedback conditions on verbal self-concept. Error bars are +/- 1 standard error of the mean.

Figure 8. Moderated Mediation Model



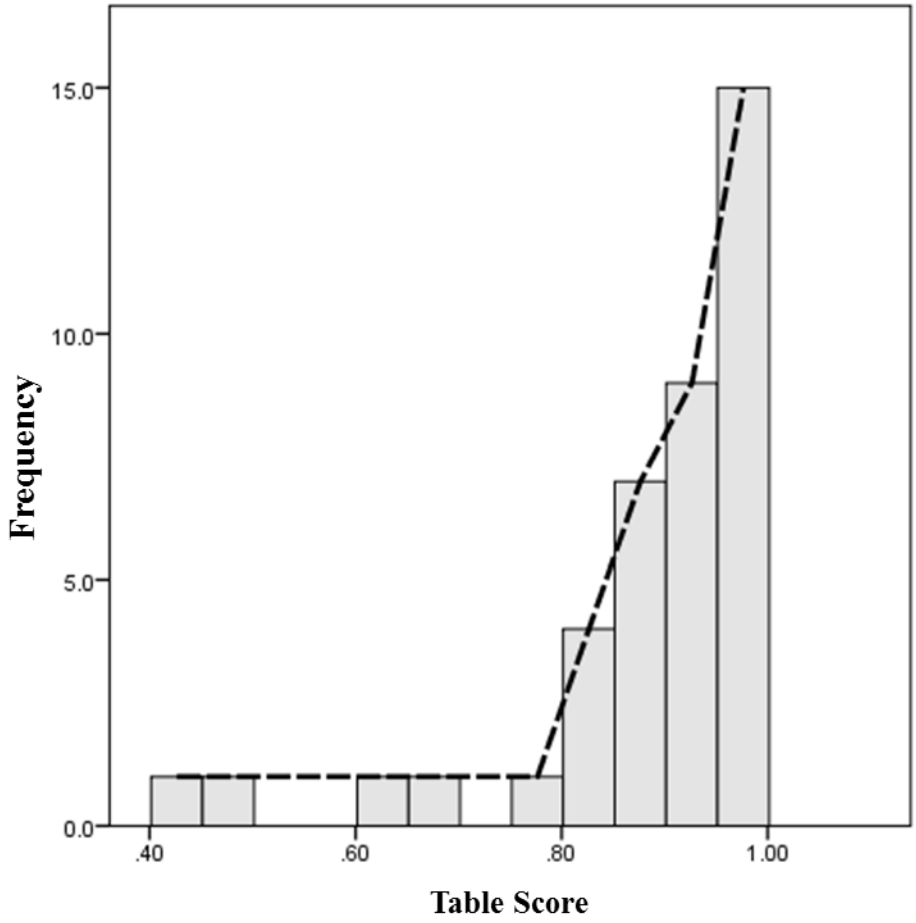
Note. For Studies 1-3, the moderated mediation model; M/V = Math/Verbal.

Figure 9. Pilot 2 Effects on DIBs



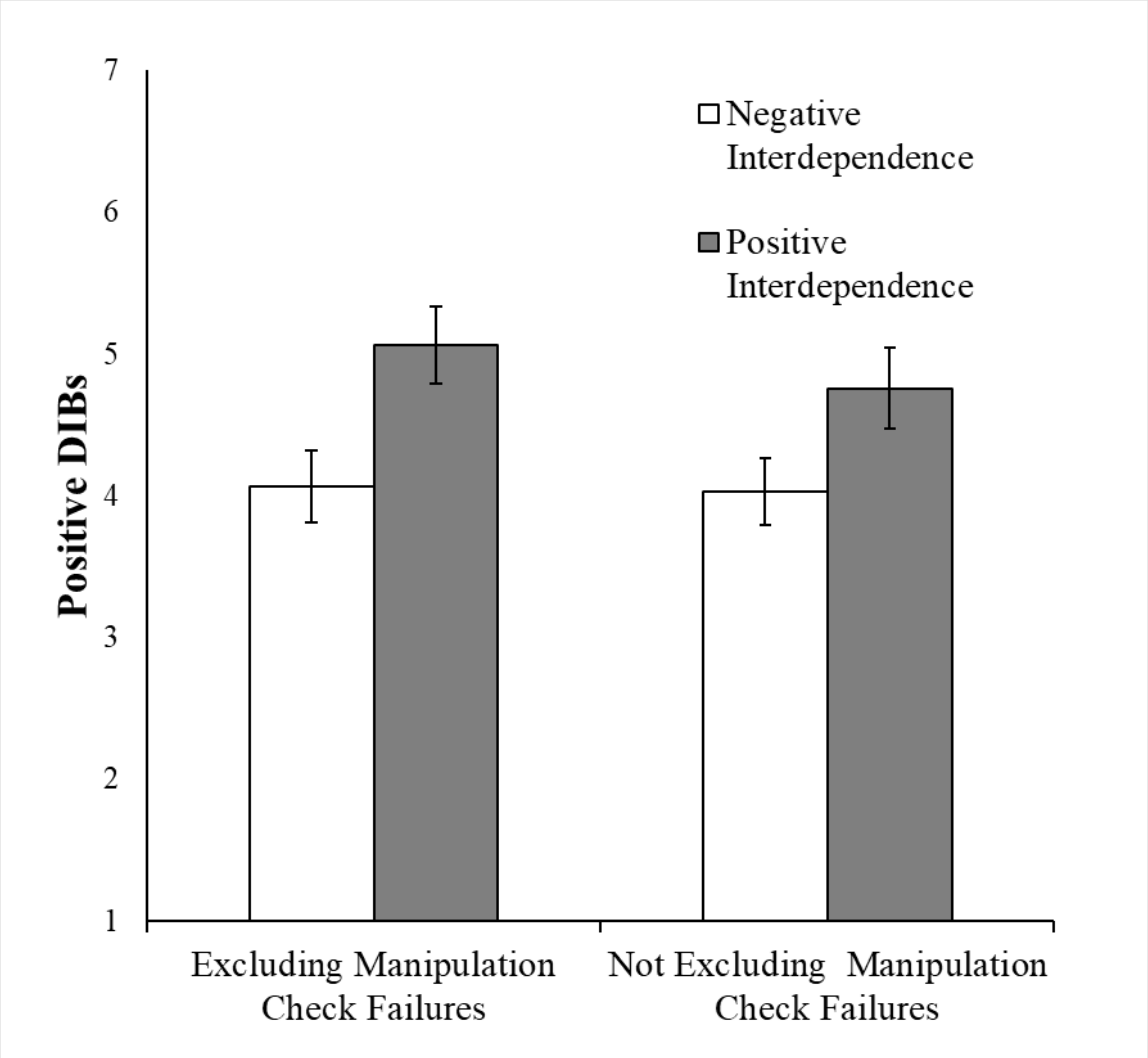
Note. In Pilot 2, math/verbal, math/science, and verbal/social studies DIBs as a function of the article manipulation interdependence condition.

Figure 10. Pilot 3 Histogram of Scores



Note. In Pilot 3, a histogram of scores on the 16 table questions, with an interpolation line. Values on the x-axis represent the proportion of questions answered correctly and values on the y-axis represent the number of participants who achieved a score in each range.

Figure 11. Pilot 3 Effects on DIBs



Note. In Pilot 3, math/verbal DIBs as a function of the table manipulation condition: positive or negative interdependence tables and exclusion of manipulation check failures.

APPENDIX B

MATERIALS

Pilot 1: Thinking Skills Test

Spoken Instructions: "The purpose of this study is to measure the basic thinking skills of students at UNCG. To help in this effort, you will be asked to complete a thinking skills test on the computer. The test you will complete has been administered to students across the country and is considered to be a valid measure of thinking skills. Furthermore, research indicates that performance on thinking skills tests is highly predictive of success in a variety of occupations including psychology, law, business, and education. The test you will complete measures thinking skills in 3 different areas: Inductive Thinking Skills, Semantic Thinking Skills, and Discrete Thinking Skills. Final scores are calculated separately for each of the 3 thinking skills areas. There are 15 questions on this test, and you will be given a total of 15 minutes to complete the test. Do you have any questions before we begin?"

Computer Instructions:
Thinking Skills Test
The Thinking Skills Test measures a student's performance in 3 areas:
Inductive Thinking Skills
Semantic Thinking Skills
Discrete Thinking Skills

Final scores are calculated separately for each of the 3 thinking skills areas.

TS1. Your sock drawer contains ten pairs of white socks and ten pairs of black socks. If you're only allowed to take one sock from the drawer at a time and you can't see what color sock you're taking until you've taken it, how many socks do you have to take before you're guaranteed to have at least one matching pair?
a) *Three, b) Twenty-One, c) Eleven, d) It cannot be determined

TS2. If you achieve something meaningful to you, you feel
a) Interested, b) Calm, c) *Proud, d) Sympathetic

TS3. A tenacious mountain goat attempts to scale a cliff sixty feet high. Every minute, the goat bounds upward three feet but slips back two. How many minutes does it take for the goat to reach the top?
a) Fifty-Six, b) *Fifty-Eight, c) Sixty, d) It cannot be determined

TS4. Arrange these words in a meaningful sequence: 1. Leaves, 2. Branch, 3. Flower, 4. Tree, 5. Fruit
a) 4, 3, 1, 2, 5, b) 4, 2, 5, 1, 3, c) 4, 3, 2, 1, 5, d) *4, 2, 1, 3, 5

TS5. Suppose you know that Mary will be in the school play only if she likes plays. Also, you know that Mary will be in the school play. Does Mary dislike plays?
a) Yes, b) *No, c) It cannot be determined

TS6. Which emotion would best help a person successfully check for errors in a spreadsheet's formulas
a) Sad, b) Anxious, c) *Contented, d) Surprised

TS7. What comes next in this series: Seven, Ten, Eight, Eleven, Nine, Twelve
a) Seven, b) *Ten, c) Twelve, d) Thirteen

TS8. Tom felt anxious, and became a bit stressed when he thought about all the work he needed to do. When his supervisor brought him an additional project, he felt
a) *Overwhelmed, b) Jittery, c) Ashamed, d) Self-Conscious

TS9. A father is four times as old as his son. In twenty years, the father will be twice as old as his son. How old is the father?

a) Twenty, b) Thirty, c) *Forty, d) It cannot be determined

TS10. Which emotion would best help a person successfully brainstorm a large number of creative ideas
a) Satisfied, b) *Interested, c) Happy, d) Calm

TS11. Isaac and Albert were excitedly describing the result of the Third Annual International Science Fair Extravaganza in Sweden. There were three contestants, Louis, Rene, and Johannes. Isaac reported that Louis won the fair, while Rene came in second. Albert, on the other hand, reported that Johannes won the fair, while Louis came in second. In fact, neither Isaac nor Albert had given a correct report of the results of the science fair. Each of them had given one correct statement and one false statement. Who actually won the fair?
a) *Johannes, b) Rene, c) Louis, d) It cannot be determined

TS12. Arrange these words in a meaningful sequence: 1. Wall, 2. Clay, 3. House, 4. Room, 5. Bricks
a) 5, 2, 1, 4, 3, b) 2, 5, 4, 1, 3, c) 1, 2, 3, 4, 5, d) *2, 5, 1, 4, 3

TS13. Suppose you know that if Mary lives in the green house, then her last name is Jones. Also, you know that Mary doesn't live in the green house. Is Mary's last name not Jones?

a) Yes, b) No, c) *It cannot be determined

TS14. What comes next in this series: Three, Four, Seven, Eight, Eleven, Twelve
a) Ten, b) Fourteen, c) Seven, d) *Fifteen

TS15. You have two cups, one containing orange juice and one containing an equal amount of lemonade. One teaspoon of the orange juice is taken and mixed with the lemonade. Then a teaspoon of this mixture is mixed back into the orange juice. Is there more lemonade in the orange juice, more orange juice in the lemonade, or are they equal?
a) There is more lemonade in the orange juice, b) There is more orange juice in the lemonade, c) *The amounts are equal, d) It cannot be determined

Pilot 1: Discrete Thinking Feedback

Below Average Feedback Conditions
--
Obtaining Discrete Thinking Skills Scores
Please wait a moment...
--
Discrete Thinking Skills Score:
259 students at UNCG have completed the Thinking Skills Test.
Your Discrete Thinking Skills performance ranked better than 21% of these students.
Your performance ranked BELOW AVERAGE.
--

Above Average Feedback Conditions
--
Obtaining Discrete Thinking Skills Scores
Please wait a moment...
--
Discrete Thinking Skills Score:
259 students at UNCG have completed the Thinking Skills Test.
Your Discrete Thinking Skills performance ranked better than 81% of these students.
Your performance ranked ABOVE AVERAGE.
--

Pilot 1: Simple Statement Manipulation

Negative Interdependence Conditions
--
Discrete Thinking Skills Overview:
Discrete Thinking is the process of conceptualizing distinct hierarchies of concepts related to the problem at hand and then seeking solutions through parallel representations.

Discrete Thinking Skills influence a variety of more well-known abilities, most notably Active Identification Ability.
People who perform WELL on tests of Discrete Thinking tend to perform POORLY on tests of Active Identification. People who perform POORLY on tests of Discrete Thinking tend to perform WELL on tests of Active Identification.
--

Positive Interdependence Conditions
--
Discrete Thinking Skills Overview:
Discrete Thinking is the process of conceptualizing distinct hierarchies of concepts related to the problem at hand and then seeking solutions through parallel representations.

Discrete Thinking Skills influence a variety of more well-known abilities, most notably Active Identification Ability.
People who perform WELL on tests of Discrete Thinking tend to perform WELL on tests of Active Identification. People who perform POORLY on tests of Discrete Thinking tend to perform POORLY on tests of Active Identification.
--

Pilot 1: Self-Concept Scales

Discrete Thinking Skills

Response options: 1(*Definitely False*) to 9(*Definitely True*)
1) I think I would find problems that use discrete thinking skills to be interesting.
2) I would hesitate to take a course that involved discrete thinking skills. (R)
3) I think I could be quite good at using discrete thinking skills.
4) I think I would have trouble understanding anything that is based upon discrete thinking skills. (R)
5) I think I would do well on tests that require discrete thinking skills.
6) I don't think I could ever be excited about discrete thinking skills. (R)

Active Identification Ability

Response options: 1(*Definitely False*) to 9(*Definitely True*)
1) I think I would find problems that use active identification ability to be interesting.
2) I would hesitate to take a course that involved active identification ability. (R)
3) I think I could be quite good at using active identification ability.
4) I think I would have trouble understanding anything that is based upon active identification ability. (R)
5) I think I would do well on tests that require active identification ability.
6) I don't think I could ever be excited about active identification ability (R)

Study 1: Verbal Reasoning Skills Test

Spoken Instructions "The purpose of this study is to measure the basic verbal reasoning skills of students at UNCG. To help in this effort, you will be asked to complete a verbal reasoning test. The test you will complete has been administered to students across the country and is considered to be highly valid measures of verbal reasoning ability. Furthermore, extensive research indicates that performance on verbal reasoning tests is highly predictive of success in a variety of occupations including psychology, law, business, and education. There are 20 questions on this verbal reasoning skills test, and you will be given a total of 15 minutes to complete the test. Do you have any questions before we begin?"

Verbal 1: In parts of the Arctic, the land grades into the landfast ice so _____ that you can walk off the coast and not know you are over the hidden sea.
A) Permanently, B) *imperceptibly, C) irregularly, D) precariously, E) slightly

Verbal 2: Kagan maintains that an infant's reactions to its first stressful experiences are part of a natural process of development, not harbingers of childhood unhappiness or _____ signs of adolescent anxiety.
A) *prophetic, B) normal, C) monotonous, D) virtual, E) typical

Verbal 3: It comes as no surprise that societies have codes of behavior; the character of the codes, on the other hand, can often be _____.
A) predictable, B) *unexpected, C) admirable, D) explicit, E) confusing

Verbal 4: Mathematicians have a distinctive sense of beauty: they strive to present their ideas and results in a clear and compelling fashion, dictated by _____ as well as logic.
A) caprice, B) *aesthetics, C) obligation, D) methodologies, E) intellect

Verbal 5: Unenlightened authoritarian managers rarely recognize a crucial reason for the low levels of serious conflict among members of democratically run work groups: a modicum of tolerance for dissent often prevents _____.
A) demur, B) *schism, C) cooperation, D) compliance, E) shortsightedness

Verbal 6: The novelist devotes so much time to avid descriptions of his characters' clothes that the reader soon feels that such _____ concerns, although worthy of attention, have superseded any more directly literary aims.
A) didactic, B) syntactical, C) irrelevant, D) *sartorial, E) frivolous

Verbal 7: Just as the authors' book on eels is often a key text for courses in marine vertebrate zoology, their ideas on animal development and phylogeny _____ teaching in this area.
A) prevent, B) defy, C) replicate, D) *inform, E) use

Verbal 8: Mechanisms develop whereby every successful species can _____ its innate capacity for population growth with the constraints that arise through its interactions with the natural environment.
A) enhance, B) replace, C) produce, D) surpass, E) *reconcile

Verbal 9: During a period of protracted illness, the sick can become infirm, _____ both the strength of the work and many of the specific skills they once possessed.
A) regaining, B) denying, C) pursuing, D) insuring
*losing

Verbal 10: The painting was larger than it appeared to be, for hanging in a darkened recess of the chapel, it was _____ by the perspective.
A) improved, B) aggrandized, C) embellished, D) jeopardized, E) *diminished

Verbal 11: Because folk art is neither completely rejected nor accepted as an art form by historians, their final evaluations of it necessarily remain _____.
A) arbitrary, B) estimable, C) orthodox, D) unspoken, E) *equivocal

Verbal 12: The modern age is a permissive one in which things can be said explicitly, but the old tradition of _____ dies hard.
A) garrulousness, B) exaggeration, C) excoriation, D) bombast, E) *euphemism

Verbal 13: Although economists have traditionally considered the district to be solely an agricultural one, the _____ of inhabitants' occupations makes such a classification obsolete.
A) productivity, B) *diversity, C) predictability, D) profitability, E) stability

Verbal 14: To ensure the development and exploitation of a new technology, there must be a constant _____ of several nevertheless distinct activities.
A) productivity, B) *interplay, C) implementation, D) comprehending, E) improvement, F) exploration

Verbal 15: Some customs travel well; often, however, behavior that is considered the epitome of _____ at home is perceived as impossibly rude or, at the least, harmlessly bizarre abroad.
A) novelty, B) eccentricity, C) *urbanity, D) coarseness, E) tolerance

Verbal 16: Given the existence of so many factions in the field, it was unrealistic of Anna Freud to expect any _____ of opinion.
A) freedom, B) reassessment, C) *uniformity, D) expression, E) formation

Verbal 17: The trainees were given copies of a finished manual to see whether they could themselves begin to _____ the inflexible, although tacit, rules for composing more of such instructional materials.
A) freedom, B) design, C) revise, D) disrupt, E) *standardize, F) derive

Verbal 18: After thirty years of television, people have become "speed watchers"; consequently, if the camera lingers, the interest of the audience _____.
A) broadens, B) begins, C) varies, D) *flags, E) clears

Verbal 19: Ironically, Carver's precision in sketching lives on the edge of despair ensures that his stories will sometimes be read too narrowly, much as Dickens' social-reformer role once caused his broader concerns to be _____.
A) *ignored, B) reinforced, C) contradicted, D) diminished, E) diversified

Verbal 20: Trapped thousands of years ago in Antarctic ice, recently discovered air bubbles are _____ time capsules filled with information for scientists who chart the history of the atmosphere.
A) inconsequential, B) broken, C) *veritable, D) resplendent, E) impenetrable

Study 1: Simple Statement Manipulation

Negative Interdependence Conditions

PREVIOUS RESULTS:
Last semester, 372 students at UNCG completed the Verbal Reasoning Test you completed today. In addition, they completed a Mathematical Reasoning Test you will not be taking.
The results showed that:
Students who performed WELL on the verbal test usually did POORLY on the mathematical test.
Students who performed POORLY on the verbal test usually did WELL on the mathematical test.

Positive Interdependence Conditions

PREVIOUS RESULTS:
Last semester, 372 students at UNCG completed the Verbal Reasoning Test you completed today. In addition, they completed a Mathematical Reasoning Test you will not be taking.
The results showed that:
Students who performed WELL on the verbal test usually did WELL on the mathematical test.
Students who performed POORLY on the verbal test usually did POORLY on the mathematical test.

Consolidation Questions

Are you surprised by the results of the previous study with UNCG students?
(Response options: I am surprised/ I am not surprised)

Why are you surprised or not surprised by the results of the previous study?
(Open text response)

Study 1: DIBs Scale

Math/Verbal DIBs:
Response options: 1 (*Strongly disagree*) to 7 (*Strongly agree*)

1. I think that some people are talented in Math whereas others are talented in Verbal Domains. (R)
2. Ability is subject-specific. People either achieve well in Math or in Verbal Domains. (R)
3. Students who are not as good in Math have their strengths in Verbal Domains. (R)
4. There are only a few people who are equally talented in Math and Verbal Domains. (R)
5. Students who do well in Math often do not achieve as well in Verbal Domains. (R)
6. A student's grades in Math and Verbal Domains tend to be quite different. (R)

Study 1: Verbal Reasoning Feedback

Below Average Feedback Conditions
--
Obtaining Verbal Reasoning Skills Scores
Please wait a moment...
--
Verbal Reasoning Skills Score:
This semester, 259 students at UNCG have completed the Verbal Reasoning Skills Test.
Your Verbal Reasoning Skills performance ranked better than 21% of these students.
Your performance ranked BELOW AVERAGE.
--

Above Average Feedback Conditions
--
Obtaining Verbal Reasoning Skills Scores
Please wait a moment...
--
Verbal Reasoning Skills Score:
This semester, 259 students at UNCG have completed the Verbal Reasoning Skills Test.
Your Verbal Reasoning Skills performance ranked better than 81% of these students.
Your performance ranked ABOVE AVERAGE.

Study 1: Self-Concept Scales

Math Self-Concept:
Response options: 1 (*Definitely False*) to 9 (*Definitely True*)
1) I think I would find problems that use Math to be interesting.
2) I would hesitate to take a course that involved Math. (R)
3) I think I could be quite good at using Math.
4) I think I would have trouble understanding anything that is based upon Math. (R)
5) I think I would do well on tests that require Math.
6) I don't think I could ever be excited about Math. (R)

Verbal Self-Concept:
Response options: 1 (*Definitely False*) to 9 (*Definitely True*)
1) I think I would find problems that use Verbal skills to be interesting.
2) I would hesitate to take a course that involved Verbal skills. (R)
3) I think I could be quite good at using Verbal skills.
4) I think I would have trouble understanding anything that is based upon Verbal skills. (R)
5) I think I would do well on tests that require Verbal skills.
6) I don't think I could ever be excited about Verbal skills. (R)

Science Self-Concept:
Response options: 1 (*Definitely False*) to 9 (*Definitely True*)
1) I think I would find problems that use Science to be interesting.
2) I would hesitate to take a course that involved Science. (R)
3) I think I could be quite good at using Science.
4) I think I would have trouble understanding anything that is based upon Science. (R)
5) I think I would do well on tests that require Science.
6) I don't think I could ever be excited about Science. (R)

Study 1: Math Importance and Interest Scales

Math Importance:
Response options: 1 (*Strongly disagree*) to 7 (*Strongly agree*)

1. It is important to me to know a great deal about mathematics.
2. It is important to me to remember information in mathematics.
3. Mathematics is important to me personally.

Math Career Interest:
Response options: 1 (*Strongly disagree*) to 7 (*Strongly agree*)

1. I would like to work in a career involving mathematics.
2. I would like to study mathematics.
3. I would like to spend my life doing advanced mathematics.
4. I would like to work on mathematics projects in the future.

Pilot 2: Filler Questions

Response options: 1(*Strongly disagree*) to 5(*Strongly agree*)

1. I see myself as someone who is talkative
2. I see myself as someone who tends to find fault with others
3. I see myself as someone who does a thorough job
4. I see myself as someone who is depressed, blue
5. I see myself as someone who is original, comes up with new ideas
6. I see myself as someone who is reserved
7. I see myself as someone who is helpful and unselfish with others
8. I see myself as someone who can be somewhat careless
9. I see myself as someone who is relaxed, handles stress well
10. I see myself as someone who is curious about many different things
11. I see myself as someone who is full of energy
12. I see myself as someone who starts arguments with others
13. I see myself as someone who is a reliable worker
14. I see myself as someone who can be tense
15. I see myself as someone who is ingenious, a deep thinker
16. I see myself as someone who generates a lot of enthusiasm
17. I see myself as someone who has a forgiving nature
18. I see myself as someone who tends to be disorganized
19. I see myself as someone who worries a lot
20. I see myself as someone who has an active imagination

Pilot 2: DIBs Scales

Note. These scales were later modified to improve reliability. All main studies use the improved measures.

Response options: 1(*Strongly disagree*) to 7(*Strongly agree*)
Math and Verbal DIBs

1. Some people are talented in math whereas others are talented in verbal domains. (R)
2. Ability is subject-specific. People either do well in math or in verbal domains, but not both. (R)
3. Students who are not good in math tend to have strong verbal skills. (R)
4. There are many people who are equally talented in math and verbal domains.
5. Students who do well in math often have high achievement in verbal domains.
6. Students' grades in math and in verbal domains tend to be quite similar.

Math and Science DIBs

1. Some people are talented in math whereas others are talented in science. (R)
2. Ability is subject-specific. People either do well in math or in science, but not both. (R)
3. Students who are not good in math tend to have strong science. (R)
4. There are many people who are equally talented in math and science.
5. Students who do well in math often have high achievement in science.
6. Students' grades in math and in science tend to be quite similar.

Social Studies and Verbal DIBs

1. Some people are talented in social studies whereas others are talented in verbal domains. (R)
2. Ability is subject-specific. People either do well in social studies or in verbal domains, but not both. (R)
3. Students who are not good in social studies tend to have strong verbal skills. (R)
4. There are many people who are equally talented in social studies and verbal domains.
5. Students who do well in social studies often have high achievement in verbal domains.
6. Students' grades in social studies and in verbal domains tend to be quite similar.

Study 2: Negative Interdependence Article

Psychology Today

People Who Excel in Verbal Domains Perform Poorly in Math

By: Ellen J. Daniels
Psychology Today October 2015
Vol. 18, p. 74-75
DOI:10.1036/psych.today.2015.10.004

Are people who are good at verbal tasks bad at math? More than 100 years since the development of standardized tests—such as the SAT and ACT—this question still rises as a topic of hot debate. However, new research in the field of educational psychology is demonstrating that the same people who are good at verbal tasks are often not good at math.

According to University of Georgia researcher Dr. Elizabeth Costello, learning mathematics is entirely different from learning oral and written language skills. Teaching mathematics, unlike other subjects, is usually not helped by oral explanations from the teacher, classroom discussions, or reading the textbook. Those with strong verbal skills depend on engaging in these verbal learning activities, which makes becoming skilled in mathematics very difficult. Furthermore, Costello has shown that mathematics relies on the ability to quickly learn and use specialized equations. Mathematics vocabulary words such as volume, ruler, plot, and product, are confusing distractions from conceptually understanding these specialized formulas. Therefore, to be mathematically proficient it can actually be beneficial to have poor verbal skills, since reliance on language can be a barrier to learning and making use of sophisticated mathematical functions.

The significant mathematics deficits caused by overdependence on language has until recently been overlooked by researchers and teachers. However, it has now become clear that the mental processes used for language are often opposed to mathematics. Dr. Susan Parker and colleagues at the University of Maryland have tracked the math and language progress of thousands of individual students for the past decade. They have conclusively shown that difficulties in math can be worsened by skill in language. Similarly, successes in math are often accompanied by problems in language. These findings fully agree with a large body of research demonstrating that math proficiency is more common in people who have disorders in language processing, such as dyslexia.

These countless educational studies are further supported by neuropsychological research conducted by Dr. Stephen DeSimone and the ALDNR unit at Stanford University. Their studies of the brain have provided a wealth of evidence showing that the primary linguistic circuits in the left angular gyrus are the same neural pathways used for the manipulation of numbers in mental math. Their findings demonstrate that mathematical mental processes are interrupted by verbal processing in the language area of the brain. Therefore, mathematical processing is dependent on suspending verbal activity. Taken together, these findings leave little doubt that there is a fundamental conflict between verbal skills and mathematical performance.

Study 2: Positive Interdependence Article

Psychology Today

People Who Excel in Verbal Domains Also Excel in Math

By: Ellen J. Daniels
Psychology Today October 2015
Vol. 18, p. 74-75
DOI:10.1036/psych.today.2015.10.004

Are people who are good at verbal tasks also good at math? More than 100 years since the development of standardized tests—such as the SAT and ACT—this question still rises as a topic of hot debate. However, new research in the field of educational psychology is demonstrating that the same people who are good at verbal tasks are also good at math.

According to University of Georgia researcher Dr. Elizabeth Costello, learning mathematics is heavily dependent on oral and written language skills. Teaching mathematics, just like every other subject, involves oral explanations by the teacher, classroom discussions, and reading the textbook. Without sufficient verbal skills to engage in these learning activities, mathematics becomes nearly impossible. Furthermore, Costello has shown that mathematics relies on the ability to quickly learn and use specialized vocabulary. Everyday words such as volume, ruler, plot, and product, take on different and more specialized meanings in mathematics. Therefore, to be mathematically proficient people must have advanced verbal skills which allow them to learn and make use of sophisticated mathematical terminology.

The numerous significant language demands of mathematics have until recently been overlooked by researchers and teachers. However, it has now become clear that the same mental processes used for language are also required for mathematics. Dr. Susan Parker and colleagues at the University of Maryland have tracked the math and language progress of thousands of individual students for the past decade. They have conclusively shown that difficulties in math are linked to problems in language. Similarly, successes in math are dependent on skills in language. These findings fully agree with a large body of research demonstrating that math issues are most often a result of disorders in language processing, such as dyslexia, not deficits in mathematical ability.

These countless educational studies are further supported by neuropsychological research conducted by Dr. Stephen DeSimone and the ALDNR unit at Stanford University. Their studies of the brain have provided a wealth of evidence showing that the primary linguistic circuits in the left angular gyrus are the same neural pathways used for the manipulation of numbers in mental math. Their findings demonstrate that mathematical mental processes require working with numbers verbally, in the language area of the brain. Therefore, mathematical processing is dependent on verbal ability. Taken together, these findings leave little doubt that there is a fundamental link between verbal skills and mathematical performance.

Pilot 3: Filler Questions

Response options: 1 (*Strongly disagree*) to 7 (*Strongly agree*)

1. If they just tried harder, all students could score well on Math.
2. Students who score poorly on Verbal would benefit from extra tutoring.
3. I am confident that I could score well on Math if I tried hard.
4. If I scored poorly on Verbal, I believe that extra tutoring would help me.

Study 3: Negative Interdependence Tables

You will be presented with 3 tables of student's scores on Math and Verbal tests and you will answer questions that assess your ability to accurately interpret the information presented in the tables. Please look over the tables and answer the questions to the best of your ability.

Table 1

Student	Math	Verbal
A	470	630
B	600	590
C	650	430
D	480	550
E	500	440
F	470	620
G	450	640
H	630	470

Table 2

Student	Math	Verbal
I	550	620
J	660	460
K	410	698
L	500	670
M	620	550
N	610	610
O	650	480
P	670	380

Table 3

Student	Math	Verbal
Q	690	590
R	710	570
S	460	710
T	800	510
U	480	750
V	590	790
W	580	610
X	670	540

Study 3: Positive Interdependence Tables

You will be presented with 3 tables of student's scores on Math and Verbal tests and you will answer questions that assess your ability to accurately interpret the information presented in the tables. Please look over the tables and answer the questions to the best of your ability.

Table 1

Student	Math	Verbal
A	470	470
B	600	620
C	650	640
D	480	440
E	500	550
F	470	590
G	450	430
H	630	630

Table 2

Student	Math	Verbal
I	550	480
J	660	670
K	410	380
L	500	460
M	620	610
N	610	550
O	650	620
P	670	698

Table 3

Student	Math	Verbal
Q	690	610
R	710	750
S	460	510
T	800	710
U	480	570
V	590	540
W	580	590
X	670	790

Study 3: Table Questions

1) In Table 1, which student scored highest on Math?
A B C D E F G H
2) In Table 1, which student scored lowest on Math?
A B C D E F G H
3) In Table 1, which student scored highest on Verbal?
A B C D E F G H
4) In Table 1, which student scored lowest on Verbal?
A B C D E F G H
5) In Table 2, which students scored above 600 on Math?
I J K L M N O P None
6) In Table 2, which students scored above 600 on Verbal?
I J K L M N O P None
7) In Table 2, which students scored above 600 on either Math OR Verbal?
I J K L M N O P None
8) In Table 2, which students scored above 600 on both Math AND Verbal?
I J K L M N O P None
9) In Table 3, which students scored below 600 on Math?
Q R S T U V W X None
10) In Table 3, which students scored below 600 on Verbal?
Q R S T U V W X None
11) In Table 3, which students scored below 600 on either Math OR Verbal?
Q R S T U V W X None
12) In Table 3, which students scored below 600 on both Math AND Verbal?
Q R S T U V W X None
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13) In which table did the fewest students score above 600 on Math?
A) Table 1, B) Table 2, C) Table 3

14) In which table did the fewest students score above 600 on Verbal?
A) Table 1, B) Table 2, C) Table 3

15) Across the 3 tables, _____ of the students who scored above 600 on Math also scored above 600 on Verbal.
A) More than half, B) Exactly half, C) Less than half

16) Across the 3 tables, _____ of the students who scored below 600 on Math also scored below 600 on Verbal.
A) More than half, B) Exactly half, C) Less than half