SCIENTIFIC REASONING ABILITY AND CHILDREN'S LEARNING OF SKILLS TAUGHT IN COGNITIVE THERAPY

By

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CHAPTER I

INTRODUCTION

Pediatric-onset depression is a recurrent and persistent disorder associated with impairment in multiple domains and increased risk for substance use disorders and suicide (Armstrong & Costello, 2002; Birmaher et al., 1996; Costello, Erkanli, & Angold, 2006; Reinecke & Curry, 2008). Therefore, finding efficacious treatments for depression in youth is of critical importance. Psychotherapies have been shown to successfully reduce depression in children and adolescents, although the overall effect size has been modest (ES=.34;Weisz, McCarty, & Valeri, 2006). Thus, there is considerable room to improve upon the outcomes of existing treatments for depression in youth.

One possible explanation for the relatively modest effects of therapy for pediatric depression is the limited attention paid to the developmental demands of the various therapeutic strategies that comprise the different interventions. Although incorporating developmental considerations into treatment planning has been recognized as important for increasing treatment efficacy (Eyberg, Schuhmann, & Rey, 1998; Ollendick, Grills, & King, 2001; Shirk, 1988), clinical researchers generally have not extended a developmental framework to interventions (Holmbeck & Kendall, 1991; Shirk, 1999). Many interventions for youth depression have been downward extensions of adult treatment approaches (Stallard, 2002). As these interventions have been derived, in part, from theories of adult psychopathology and therapy, the extent to which these treatments are appropriate for less cognitively developed individuals is unclear.

Differences in treatment efficacy have been found as a function of age, with effect sizes generally larger for adolescents than for children (Durlak, Furhman, & Lampman, 1991; Weisz, Weiss, Han, Granger, & Morton, 1995). Clinical researchers, therefore, have highlighted the importance of recognizing and studying age-related differences in treatment response (Furman, 1980), although no studies have explicitly assessed children's developmental level, separate from age, or have tested whether development moderates treatment outcomes (Eyberg, et al., 1998; Holmbeck, O'Mahar, Abad, Colder, & Updegrove, 2006). The terms "age" and "development" are often used interchangeably, but they are not synonymous (Durlak & McGlinchey, 1999; Holmbeck & Kendall, 1991). Development is significantly more complex and heterogeneous than the linear progression of chronological age; that is, children of the same age often differ in their level of development in various domains (Sauter, Heyne, & Westenberg, 2009; Weisz, Weiss, Alicke, & Klotz, 1987). Therefore, use of developmental level to guide treatment decisions may decrease erroneous assumptions based on age alone (Durlak, et al., 1991; Holmbeck & Kendall, 1991).

Furman (1980) described the state of developmental tailoring of interventions as follows:

> It should be emphasized that we are not arguing that behavioral investigators have cavalierly applied the same treatment program to children and adults of all ages. Such an argument is patently false. It is our position, however, that the developmental modifications of treatment programs have been based almost exclusively on subjective judgments rather than on empirical evidence. (p.2)

Although, recognition of the importance of developmental factors in therapy has increased over the last two decades (Holmbeck, et al., 2006), the construction of developmentally sensitive treatment strategies generally has continued to be mostly informal and superficial (e.g., linguistic changes, child-friendly materials), rather than systematic and empirically-driven (Masten & Braswell, 1991; Ollendick, et al., 2001).

Cognitive behavioral therapy (CBT) is one of the most efficacious treatments for youth depression (Weisz, et al., 2006). One common, *informal* recommendation for developmentally tailoring CBT has been to only use the core cognitive techniques (i.e., identifying thinking errors, examining underlying beliefs, and using Socratic questioning) with more cognitively advanced youth (Harrington, 2005; Siqueland, Rynn, & Diamond, 2005; Stallard, 2009). The extant research examining the relation between "development" and therapeutic efficacy, however, has not actually measured cognitive development; rather age typically has been used as a rough estimate of developmental level (Doherr, Reynolds, Wetherly, & Evans, 2005; Eyberg, et al., 1998). Empirical studies have not yet examined variations in the efficacy of cognitive techniques based on a child's level of cognitive development. That is, studies of developmentally sensitive treatments have neither explicitly assessed cognitive development nor examined its relation to the ability to learn specific therapeutic skills. This paucity of research may be due, in part, to the fact that "cognitive development," encompasses a wide array of abilities that may be uniquely linked to clinical skills and follow distinct developmental trajectories.

Scientific Reasoning

One specific area of cognitive development that likely is integral for successful participation in cognitive therapy (CT) is scientific reasoning (Sandberg & McCullough, 2010), which involves systematically testing predictions by using evidence to examine theories and drawing conclusions based on this examination (Kuhn, 2002; Sandberg & McCullough, 2010). CT skills that involve differentiating thoughts (i.e., theories) from evidence, examining evidence, and modifying thoughts (i.e., drawing conclusions) based on this evidence require such scientific reasoning. Effective use of scientific reasoning strategies, however, typically does not begin until around 5th grade and continues to progress well into adulthood (Klahr, Fay, & Dunbar, 1993; Kuhn et al., 1988; Kuhn, Schauble, & Garcia-Mila, 1992).

Acquiring, examining, and using evidence. The ability to investigate data systematically is particularly relevant for engaging in evidence examination during the CT skill of cognitive restructuring. Children who lack this ability may struggle with the central task of asking "What is the evidence?" that a certain belief is actually true. The ability to conduct appropriately controlled tests when given multiple variables to manipulate emerges between 5th and 6th grade (Bullock & Ziegler, 1999). Younger children tend to use inefficient strategies (e.g., changing all variables at once), whereas by middle school, youth begin to use and discover the utility of more efficient strategies, such as the control of variables strategy (i.e., holding all but one variable constant; Tschirgi, 1980). However, they continue to use both this valid approach and other less valid strategies in different contexts (Garcia-Mila & Andersen, 2007; Gleason & Schauble, 1999; Kuhn, Iordanou, Pease, & Wirkala, 2008; Kuhn, et al., 1992; Schauble, 1990). In cognitive therapy, children who use invalid reasoning strategies are likely to have difficulty examining evidence or searching for alternative explanations in order to modify their cognitive distortions.

Another aspect of scientific reasoning that likely impacts children's ability to use CT skills is the ability to modify one's beliefs appropriately when confronted with evidence inconsistent with those beliefs. The ability to set aside a prior belief in order to accurately and objectively evaluate evidence develops over the course of childhood and into adulthood (Amsel & Brock, 1996; Kuhn, et al., 1988). Children are more likely than adults to ignore or distort evidence that does not fit with an existing belief (Kuhn, et al., 1988; Schauble, 1996). Children also tend to justify their inferences with prior theories or a mixture of theory and evidence, whereas adults are more likely to justify inferences with evidence (Kuhn & Dean, 2004). In addition, middle school-age youth have particular difficulty accurately observing phenomena when the data are inconsistent with their beliefs (Chinn & Malhotra, 2002), which is especially relevant to their ability to modify cognitive distortions based on observations of contradictory information.

Epistemological understanding. Children's development of epistemological understanding – the awareness of the process of reasoning and of the separation between theory and evidence -- is another aspect of scientific reasoning development likely to affect the ability to modify beliefs based on evidence gathering. Epistemological understanding includes knowledge that two people can hold different beliefs, and though neither belief is absolutely "right" nor "wrong," some beliefs are more valid, as they have more supporting evidence (Kuhn, et al., 2008; Kuhn & Pearsall, 1998). Understanding of the relation between evidence and theory (both prior belief and integrated inferences) progresses from childhood to adulthood.

Three levels of epistemological understanding develop from middle childhood into adulthood (Kuhn, et al., 2008; Kuhn & Pearsall, 1998). At the absolutist level, individuals understand that two people can hold different beliefs, but they also think that one of these beliefs is objectively wrong and can be corrected using accurate information. At the multiplist level of epistemological understanding, one realizes that even with knowledge, people can still disagree, because knowledge has a subjective component. At this level, however, all knowledge is viewed as opinion, so neither party is believed to be right or wrong. Finally, at the evaluativist level, there is an understanding that some opinions are more "right" than others based on the facts that support them (Kuhn, et al., 2008; Kuhn & Pearsall, 1998).

Thus, scientific reasoning abilities are likely essential for effectively engaging in the CT skills used for treating depression. These abilities mature substantially in early adolescence. During this period, however, scientific reasoning skills also show intra- and inter-individual variation, such that changes do not always follow a consistent age-related progression (Kuhn, Cheney, & Weinstock, 2000; Zimmerman, 2007). That is, children of the same age may perform differently on the same tasks, and some adults may struggle with certain reasoning tasks that younger individuals can do (Kuhn, 2002; Zimmerman, 2007). For example, Kuhn and colleagues (2000) found that some children in grades 2 and 3 demonstrated an evaluativist level of thinking, whereas more than half of the adults in their study stayed in the multiplist level of reasoning. Because of this within and across-age variability in reasoning skills, an accurate assessment of a child's specific level of reasoning ability likely will be more informative than age when trying to determine whether a child is cognitively ready for interventions that require such reasoning.

Development and Treatment

Effectively adapting therapy for depression to children's level of cognitive development involves bridging developmental and clinical research by connecting specific therapeutic skills with the developmental abilities necessary for engaging in them. Whereas treatment studies provide the scientific basis for selecting the most efficacious approaches for improving symptoms, developmental research supplies the empirical information about the emergence and growth of various developmental abilities over time. The gap between these two relatively insular fields has been highlighted for several decades but without much progress empirically (Holmbeck & Kendall, 1991; Shirk, 1988). Although the relation between development and therapy is most important for children experiencing psychopathology, a tenet of developmental psychopathology is to base our understanding of clinical phenomena within the framework of typical development. As such, a first step is to examine these relations in a normative sample. The current study aimed directly to connect these areas of research in a normative sample, and to answer the question: Does developmental level predict children's ability to learn therapeutic skills?

Several other important and as of yet unexamined questions also can be addressed through this translational research. First, is cognitive development related to the knowledge of CT skills, prior to any formal instruction or learning about the skills? In the absence of psychological symptoms, the kinds of cognitive skills taught in CT, such as cognitive restructuring, may develop normatively over time, so that individuals who are more cognitively developed will demonstrate more knowledge of these skills. To date, however, no research has explicitly examined the relation of cognitive development and knowledge of CT skills.

Second, is knowledge of CT skills (prior to formal instruction or learning) related to symptoms of psychopathology? One assumption underlying skills-based therapeutic interventions is that children who are experiencing psychological symptoms (and therefore entering therapy) are deficient in their knowledge of or readiness to learn the skills being taught in CT, but that acquiring these skills will reduce symptoms. No empirical evidence exists, however, linking symptoms to knowledge of specific therapeutic skills. For example, evidence that children who have cognitive distortions are at risk for developing depression (Abela & Hankin, 2011) has led to treatments that teach children how to restructure these distortions. No research has yet examined whether children with these distortions are actually more deficient in their ability to restructure their thoughts as compared to children without such distortions. Thus, the relation between symptoms of psychopathology and knowledge of therapeutic skills remains to be studied.

If less cognitively developed children have less knowledge of CT skills, and if deficiencies in this knowledge are related to symptoms, then less cognitively developed children might have more symptoms. On the other hand, some researchers have suggested that more advanced cognitive development (e.g., the ability to think about one's thinking; Bell, Wieling, & Watson, 2004) actually may increase children’s risk for developing psychopathology because they have the ability to contemplate future negative outcomes and engage in more complex self scrutiny. The relation between children’s cognitive developmental level and extent of their symptoms has yet to be examined empirically.

Abstract Reasoning and CBT

In addition to scientific reasoning, many other types of reasoning (e.g., causal, hypothetical, analogical, and abstract) may be important for successful participation in CBT (Grave & Blissett, 2004; Harrington, Wood, & Verduyn, 1998; Oetzel & Scherer, 2003). Scientific reasoning in which contextual information is used to draw conclusions about one’s surroundings may be more relevant to the learning of CBT skills than abstract reasoning in which abstract thinking and rule understanding are used to derive a single correct answer from a set of given premises (Harrington, et al., 1998). Still, as the reasoning required by CBT is complex, formal abstract reasoning may be important for engaging in some aspects of CBT (Holmbeck, et al., 2006; Oetzel & Scherer, 2003; Ollendick, et al., 2001). Therefore, the current study examined abstract reasoning ability separate from scientific reasoning ability, in order to examine the relation of each type of reasoning to learning of CBT skills.

Homework Completion in CBT

Another important area of study is the relation between homework completion and therapeutic outcomes in CBT. Most CBT interventions for depression include a homework component (Kazantzis, Deane, Ronan, & L'Abate, 2005; Weisz, Jensen Doss, & Hawley, 2005), because it is an essential element of treatment that allows individuals to practice, master, and generalize new CBT skills outside of therapy session (Gaynor, Lawrence, & Nelson-Gray, 2006; Kazantzis, Whittington, & Dattilio, 2010; Simons et al., 2012; Thase & Callan, 2006) Homework adherence and completion are significantly related to positive outcomes in adult CBT (Kazantzis, et al., 2010). The relation between homework completion and therapy outcomes in children and adolescents has received less attention, although some evidence exists that completion of homework predicts decreases in depression, hopelessness, and suicidal ideation in adolescents (Simons, et al., 2012).

Both adherence to homework assignments and individual patient characteristics may impact the relation between homework completion and therapeutic outcomes. Measurement of homework adherence has varied across studies, from dichotomous variables to continuous measures of the extent to which completed homework is consistent with the tasks assigned. Quality, rather than quantity, of homework completed has also been examined, with better adherence to the homework assignment being associated with larger decreases in symptoms (Gaynor, et al., 2006; Kazantzis, et al., 2005; Simons, et al., 2012; Thase & Callan, 2006).

Patient characteristics also may moderate the relation of homework adherence to treatment outcomes. For example, the relation between completing homework and improved outcomes was found to be strongest for individuals who were more severely depressed at the beginning of treatment (Neimeyer & Feixas, 1990; Persons, Burns, & Perloff, 1988). Other individual characteristics that have been linked to homework adherence include personality pathology and preference for active coping strategies (Detweiler & Whisman, 1999). The association between homework completion and therapeutic outcomes in children and adolescents may vary as a function of children's level of cognitive development. As homework completion is essential to the consolidation of learning in CBT, the current study examined cognitive development as a potential moderator of the relation between homework and learning.

The Current Study

The current study examined the following research questions and hypotheses:

Primary questions.

A. Does level of scientific reasoning predict the extent of learning of cognitive therapy (CT) skills? *Hypothesis 1*: Controlling for baseline knowledge and IQ, higher levels of scientific reasoning will predict significant increases in knowledge of CT skills after the teaching session.

B. Does level of scientific reasoning improve the prediction of learning, over and above age? *Hypothesis 2*: Controlling for age, baseline knowledge, and IQ, higher levels of scientific reasoning will predict significant increases in knowledge of CT skills after the teaching session.

C. Does level of scientific reasoning predict retention of knowledge of CT skills one week later? *Hypothesis 3*: Controlling for baseline knowledge and IQ, higher levels of scientific reasoning will predict significant increases in knowledge of CT skills at the one-week follow-up.

D. Does level of scientific reasoning improve the prediction of retained learning, over and above age? *Hypothesis 4:* Controlling for age, baseline knowledge, and IQ, higher levels of scientific reasoning will predict significant increases in knowledge of CT skills at the one-week follow-up.

Secondary questions.

A. Abstract reasoning

1. Does abstract reasoning predict immediate or retained learning, over and above age? This question is exploratory; no directional hypothesis is being made here.

B. Relations among scientific reasoning, knowledge of therapeutic skills, and symptoms of psychopathology

2. Are level of scientific reasoning and knowledge of CT skills related? *Hypothesis 5*: At the baseline assessment, level of scientific reasoning and knowledge of therapeutic skills will be significantly, positively correlated.

3. Is knowledge of CT skills related to symptoms of psychopathology? *Hypothesis 6*: The relation between knowledge of CT skills and symptoms of psychopathology will be significant and negative.

4. Is level of scientific reasoning related to symptoms of psychopathology? This question is exploratory; no directional hypothesis is being made here.

C. Moderators of the relation between homework performance and retained learning.

5. Does scientific reasoning moderate the relation between homework performance and retained learning of therapeutic skills? *Hypothesis 7:* Controlling for age, baseline knowledge, and IQ, the interaction between level of scientific reasoning and homework performance will significantly predict the extent of knowledge of CT skills at follow-up. The relation between homework performance and learning of CT skills will be stronger for individuals with more advanced scientific reasoning.

6. Does abstract reasoning moderate the relation between homework performance and retained learning of therapeutic skills? This question is exploratory; no directional hypothesis is being made here.

CHAPTER II

METHOD

Participants

Participants were 234 children (57.7% male), ages 9 to 16 (*Mean* = 12.80; *SD* = 1.92), recruited from local elementary, middle, and high schools. Letters explaining the study and consent forms were sent home to parents. All children for whom parental consent was obtained were invited to participate. Participants were 82.1% Caucasian, 7.7% African American, 6.4% Multi-racial, and 3.9% other races; 4.7% of the sample was Hispanic. IQ's ranged from 68 to 146 (Mean=105.17; SD=14.11). Nine participants with IQ's less than or equal to 80 were excluded from all analyses, as these participants were likely unable to adequately understand and complete all study measures, leaving a final analytic sample of 225 participants.

Measures

Scientific Reasoning. (a) A modified version of Tschirgi's (1980) story problem set was used to assess children's understanding of effective experimentation strategies. For eight multivariate stories about familiar events (e.g., baking a cake), participants were presented with a description of a character attempting to achieve a goal (e.g., bake a cake), and three binary variables the character could use to accomplish this goal (e.g., sweetener = sugar or honey; shortening = margarine or butter; flour = white or whole-wheat). Children were then informed of the outcome of the event (e.g., good or bad tasting cake), and the character's hypothesis that a particular variable was responsible for the outcome (e.g., using honey made the cake taste good, but the type of shortening and flour made no difference). Finally, children were given three multiple choice options, and asked to select the best way for the character to prove his or her hypothesis.

Each of the multiple choice options related to a different experimental strategy (i.e., holding all but one variable constant, varying all but one variable, or changing all variables). Only the strategy of holding all but one variable constant (i.e., Control of Variables Strategy – CVS) allows one to test the hypothesis accurately. Children were given a score of 1 for choosing this strategy, and a score of 0 for choosing either of the other two options, for each of the eight stories. Scores for “good-outcome” stories were summed, as were scores for “bad-outcome” stories, resulting in two scores -- CVS-positive and CVS-negative -- each ranging from 0 to 4.

(b) The Epistemological Understanding Task (EUT; Kuhn, et al., 2000) was used to assess children’s epistemological understanding (i.e., understanding of the distinction between theory and evidence). Children were presented with statements about two individuals’ differing beliefs (e.g., “Robin believes one book’s explanation of how the brain works. Chris believes another book’s explanation of how the brain works”). Children were then asked to decide if only one of these views could be right (indicating the absolutist level), or if “both could have some rightness.” If children indicated that both could have some rightness, they were asked whether one view could be more right than the other. Determining that one view *could not* be more right than the other indicates a multiplist level of epistemological understanding, whereas determining that one view could be more right than the other indicates the most advanced evaluativist level of epistemological understanding. Children answered 3 questions in each of 4 domains (i.e., aesthetic judgments, value judgments, truth about the social world, and truth about the physical world). Children received a 0 for responses that fell in the absolutist level, a 1 for the multiplist level, and a 2 for the evaluativist level. All 12 responses were summed to give a total epistemological understanding score (i.e., EUT Total). Coefficient alpha for this sample was .69.

Abstract Reasoning. The most common measure of abstract reasoning is matrix or pattern reasoning, in which individuals are presented with a series of related designs or pictures and asked to identify the "missing" piece through reasoning about the pattern (e.g., Wechsler Intelligence Scale for Children: Matrix reasoning – Wechsler, 2003; Kaufman Assessment Battery for Children-II: Pattern Reasoning – Kaufman & Kaufman, 2004; Differential Aptitude Tests: Abstract Reasoning – Bennett, Seashore, & Wesman 1959; Raven's Progressive Matrices – Raven, Raven, & Court, 1996). The Matrix Reasoning subtest of the WISC-IV (Wechsler, 2003), which measures children's nonverbal abstract and analogical reasoning ability, was administered in order to examine whether a measure of another type of reasoning ability (i.e., abstract) besides scientific reasoning also was related to learning or retaining CT skills.

Symptoms of Psychopathology. The Children's Depression Inventory (CDI; Kovacs, 1992) was used to measure children's self-reported symptoms of depression. The suicide item was removed due to concerns of school administrators. Each of the remaining 26 items lists three statements in order of symptom severity. Internal consistency, test-retest reliability, and convergent validity have been well-documented for the CDI (Kovacs, 1992). Coefficient alpha for the CDI in this sample was .82.

The Youth Self-Report (YSR; Achenbach & Rescorla, 2001) contains 112 items assessing both internalizing and externalizing symptoms. The suicide item was excluded on this measure as well. Raw scores on three syndrome scales (i.e., Anxious/Depressed, Withdrawn/Depressed, Somatic Complaints), three DSM-Oriented Scales (i.e., Affective Problems, Anxiety Problems, and Somatic Problems) and three broad scales (i.e., Internalizing

Problems, Externalizing Problems, Total Problems) were examined in the current study. Internal consistency for the YSR ranges from α=.71-.95 (Achenbach & Rescorla, 2001).

The Screen for Child Anxiety Related Emotional Disorders (SCARED; Birmaher et al., 1997) is a 41-item self-report measure of symptoms of anxiety for children ages 8 and older. Responses are scored on a 3-point Likert scale, and yield 5 subscales (i.e., Panic, GAD, Separation Anxiety, Social Anxiety, and School Avoidance) and a total score. The current study examined the SCARED total score. The SCARED has good internal consistency and test-retest reliability (α=.90; ICC=.86; Birmaher, et al., 1997). Coefficient alpha for the total score for this sample was .91.

Intelligence Quotient (IQ). As children's ability to learn is affected by their IQ, IQ was measured and controlled for in all analyses. The Wechsler Intelligence Scale for Children - Fourth Edition (WISC-IV; Wechsler, 2003), the most widely used individual intelligence test for children, yields a Verbal Comprehension Index (VCI) and a Perceptual Reasoning Index (PRI). A two-subtest short form for the WISC-IV, which contains one subtest from the VCI (i.e., Vocabulary subtest) and one subtest from the PRI (i.e., Block Design subtest) has been shown to correlate about .90 with the full-administration Full Scale IQ (Sattler, 2008). The Vocabulary subtest measures word knowledge and verbal comprehension; the Block Design subtest taps the ability to analyze visually presented information and understand visual-spatial information. These two subtests were combined to provide an estimate of children's overall IQ.

Knowledge of Therapeutic Skills (KnoTS). No formal measure of children's knowledge of the therapeutic skills taught in cognitive therapy (CT) programs for depression exists. Based on the skills taught in the first three sessions of the Penn Resiliency Program (PRP; Jaycox, Reivich, Gillham, & Seligman, 1994; see Procedure for more information about PRP), we created a measure of children's knowledge of therapeutic skills (Knowledge of Therapeutic Skills - KnoTS; Frankel, Gallerani, & Garber, unpublished). KnoTS items were designed to assess children's understanding of the cognitive model, cognitive distortions, and cognitive restructuring. The measure included multiple choice questions and open-ended questions that were coded for accuracy. Four equivalent forms of the KnoTS (A, B, C, and D) were created to be administered during the procedure (see details below).

Procedure

Session 1. Fifty-four small groups of two to six participants (*Mean*=4.33; *SD*=1.21) attended a 3.5 hour session after school or during school break. All participants first completed a form of the KnoTS (KnoTS.1), to measure their baseline knowledge of CT skills. The session was then divided into two parts, "Assessment" and "Teaching," counterbalanced by group. In the assessment part of the session, the CDI, YSR, SCARED, CVS, and EUT were administered. In the teaching part, children were taught a condensed version of the first three sessions of PRP, an established, efficacious group early intervention program for depression in children ages 8 to 15 (Jaycox, et al., 1994; Yu & Seligman, 2002). The first three sessions of PRP focus on CT skills, specifically understanding the cognitive model, cognitive distortions, and cognitive restructuring. Material from the PRP manual for these sessions was consolidated into one 90-minute teaching session. Participants completed a different form of the KnoTS after completing the assessment part of the session and after completing the teaching part of the session (KnoTS.2 and KnoTS.3). Participants then were given homework worksheets to complete over the next week that were based on the material taught in the teaching part of the session.

Session 2. One week after session 1, participants returned for a one hour individual session after school or during school break. During this session, children completed a fourth form of the KnoTS (KnoTS.4) to assess their sustained knowledge of the CT skills. See Table 1 for a summary of when each KnoTS was administered. The four forms of the KnoTS (i.e., A, B, C, and D) were counterbalanced across administrations. The IQ subscales also were administered and completed homework was collected during session 2. Twelve participants did not participate in session 2 because they withdrew from study (n = 4), we were unable to contact the parent (n = 4), or we were unable to make an appointment for the second session due to scheduling conflicts with the families (n = 4). These individuals did not differ from participants who completed both sessions regarding any demographic, predictor, or outcome variables. As IQ data were not collected for these 12 participants, they were excluded from analyses that controlled for IQ.

Table 1. Order of KnoTS Administration, Teaching Part, Assessment Part, and Session 2

Group 1:	Teach First	KnoTS.1	Teach	KnoTS.2	Assess	KnoTS.3	Session 2	KnoTS.4
Group 2:	Assess First	KnoTS.1	Assess	KnoTS.2	Teach	KnoTS.3	Session 2	KnoTS.4

Note. Shaded cells were used as "post-teaching" scores.

Preliminary Analyses

KnoTS and Homework Coding Reliability. Two independent raters coded twenty percent of the KnoTS and the homework. The average intraclass correlation coefficient (ICC) for all KnoTS items was .92 (range = .73 to 1.0). The average ICC for all homework items was .95 (range = .80 to 1.0). Scores on all homework items were summed to create the "Homework Performance" variable.

KnoTS Subscales. To test for differences in difficulty of coded items across KnoTS forms, analyses of covariance were run, with form (i.e., A, B, C, or D) as the between subjects factor and individual coded items as the dependent variables. All ANCOVAs controlled for participant age and IQ. Four items that varied significantly by form at baseline (i.e., KnoTS.1) were dropped from further analyses.

Coded KnoTS scores were then submitted to an exploratory factor analysis. Parallel analysis (Fabrigar, Wegener, MacCullum, & Strahan, 1999; Horn, 1965; O'Connor, 2000) indicated that six factors should be extracted from the data, whereas Velicer's MAP test (Velicer, Eaton, & Fava, 2000) suggested that two factors should be extracted. Using principal axis factor analysis with oblique, promax rotation, two-, three-, four-, five-, and six-factor solutions were examined. The three-factor model was the most interpretable and had the fewest cross loadings. Factor loadings and correlations for the three-factor model are listed in Table 2. Based on the component items loading on each factor, the three factors were labeled: (1) Generating and Connecting Problem Situations, Feelings, and Behaviors; (2) Understanding Healthy Thoughts Related to Problem Situations; (3) Connecting Own Problem Situation and Feeling.

Table 2. KnoTS Item Factor Loadings

Loadings for Factors	I	II	III
Factor I: Generating and Connecting Problem Situations, Feelings, and Behaviors			
1. Generating behavior with provided distortion	**.548**	-.156	.031
2. Generating behavior with healthy thought	**.451**	.195	.063
3. Generating feeling with own distortion	**.623**	-.332	.102
4. Generating behavior with own distortion	**.710**	-.036	-.068
5. Connecting own problem situation, distortion, feeling and behavior	**.522**	.141	.004
6. Generating feeling with own healthy thought	**.448**	.029	-.006
7. Generating behavior with own healthy thought	**.693**	.047	-.043
8. Connecting own problem situation, healthy thought, feeling, and behavior	**.637**	.339	-.043
Factor II: Understanding Healthy Thoughts Related to Problem Situations			
1. Generating own problem situation	.116	**.415**	.058
2. Generating healthy thought with provided problem situation and distortion	-.207	**.828**	.034
3. Generating healthy thought with own problem situation and distortion	.253	**.468**	-.112
Factor III: Connecting own Problem Situation and Feeling			
1. Generating own problem situation	-.079	.086	**.437**
2. Generating own feeling	.143	-.171	**.693**
3. Connecting own problem situation, thought, feeling	-.028	.196	**.907**
Dropped Items			
1.Generating thought to connect given problem situation and feeling	.042	-.010	-.003
2. Generating thought connected to own problem situation and feeling	-.156	.165	.111
3. Generating feeling with healthy thought for provided problem situation	.207	.109	.195
4. Generating distortion for own problem situation	-.026	.210	.107

Note. Bold items indicate factor loadings >.35. Items that did not have any factor loadings >.35 were dropped.

In addition, to these three factors, three conceptually based scales were created. The first, “Understanding Connections among Problems Situations, Thoughts, Feelings, and Behaviors” (alpha = .54) was created from coded items, in order to examine participant’s ability to connect these four elements, an essential component of CT. The second conceptual scale was created from non-coded multiple-choice KnoTS items, which were not included in the factor analysis because individual items varied across forms. To test for equivalence of difficulty across forms for these multiple choice items, an ANCOVA was run (controlling for age and IQ), with form (i.e., A, B, C, or D) as the between subjects factor and KnoTS.1 total multiple choice score as the dependent variable. Results indicated a significant difference across forms of the KnoTS (F =

6.71, df = 3, p<.001). Post-hoc comparisons showing which forms differed significantly were examined. Individual item difficulties were calculated based on the percentage of participants who correctly answered each item. A single item was deleted from each form to make the forms equivalent in difficulty. Specifically, forms B and C were found to be significantly easier than form D. As such, the easiest item was removed from forms B and C, and the hardest item was removed from form D. An intermediate item was removed from form A so that all forms had the same number of items. Participants multiple choice score, which assessed their "General Knowledge" of CT skills, was then calculated by summing the remaining items. Finally, a "Total Knowledge" score was created by summing all KnoTS items that did not vary significantly across forms.

ANCOVAs were then run with form as the between subjects factor and each KnoTS subscale score as the dependent variable, controlling for age and IQ. There were no significant differences by form for any of the KnoTS subscales. See Table 3 for a summary of all KnoTS scales. Means, standard deviations, and correlations for all variables can be found in Appendix A (see Table A1).

Table 3. Summary of KnoTS Scales

KnoTS Scale Name	**Method of creation**	**Coefficient Alpha**
Generating and Connecting Problem Situations, Feelings and Behaviors	factor analysis	.81
Understanding Healthy Thoughts Related to Problem Situations	factor analysis	.61
Connecting Own Problem Situation and Feeling	factor analysis	.71
Understanding Connections among Problem Situations, Thoughts, Feelings and Behaviors	conceptual	.54
General Knowledge	conceptual	.45
Total Knowledge (sum of all items)	conceptual	.75

KnoTS Practice Effects. To test whether changes in KnoTS scores following the teaching session were due to learning or practice effects (i.e., from taking the KnoTS a second time), KnoTS.2 scores for groups 1 and 2 were compared (see Table 1). A linear regression analysis was conducted with group (i.e., assessment first vs. teaching first) predicting KnoTS.2 Total Knowledge score, controlling for age, IQ, and KnoTS.1 Total Knowledge score. Results indicated a significant effect of group on KnoTS.2 Total Knowledge score ($F=34.93$, $p<.001$; Adjusted $R^2 = .39$; $B=1.39$, $p=.002$), such that individuals who completed the teaching session first had significantly higher KnoTS.2 scores than those who completed the assessment session first (see Figure 1).

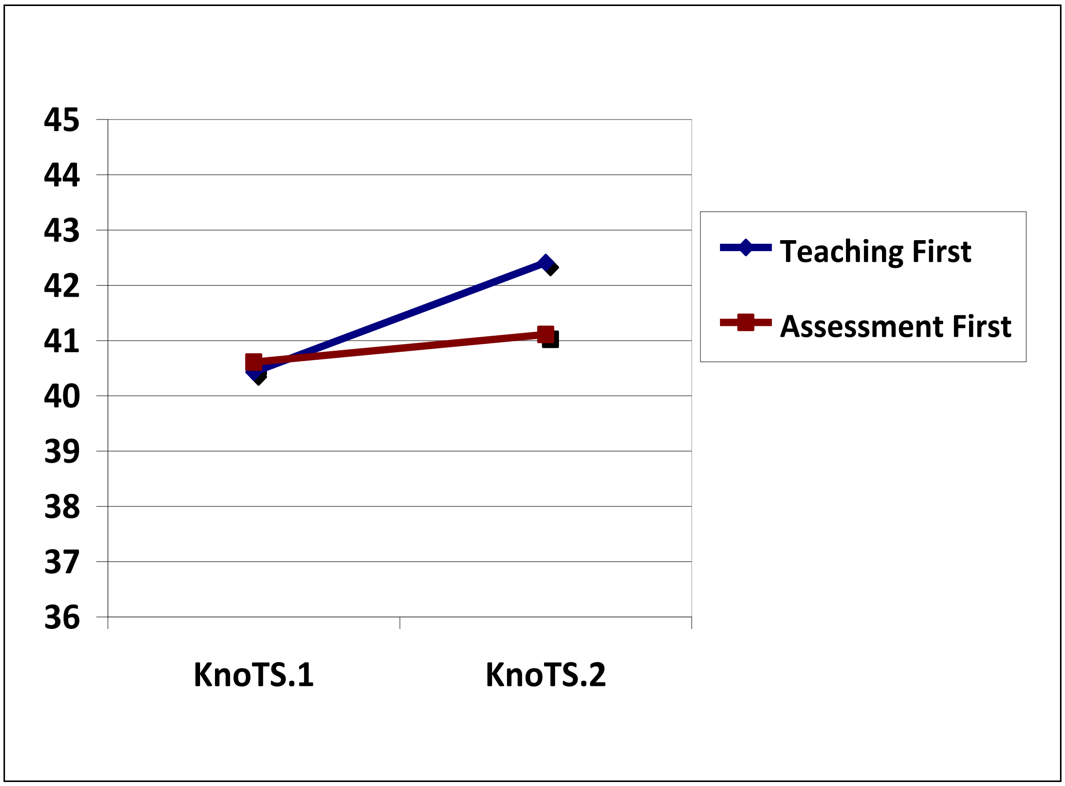

Figure 1. Effect of group (i.e., order of teaching vs. assessment) on KnoTS.2 scores

CHAPTER III

RESULTS

Primary Questions

Does level of scientific reasoning predict the extent of learning of CT skills? Does level of cognitive development improve the prediction of learning, over and above age? To examine whether scientific reasoning predicted post-teaching knowledge, linear regression analyses were conducted with scientific reasoning as the independent variable and post-teaching knowledge (KnoTS.2 for group 1 and KnoTS.3 for group 2; see Table 1) as the dependent variable. Separate regression analyses were conducted for each scientific reasoning subscale (i.e., EUT Total, CVS-positive, CVS-negative) predicting each subscale of the KnoTS. All analyses controlled for baseline knowledge (KnoTS.1) and IQ.

To examine whether scientific reasoning incremented the prediction of learning over and above age, linear regression analyses were conducted with age, IQ, and KnoTS.1 score entered in the first step, and scientific reasoning entered in the second step. The pattern of results was the same for analyses controlling and not controlling for age. As such, only the analyses controlling for age are described below. In all analyses, to control for family-wise error rates, Bonferroni corrections were used for each "set" of analyses (i.e., each scientific reasoning scale predicting 6 different KnoTS subscales; $p = .05/6 = .008$).

More advanced scientific reasoning predicted higher post-teaching scores, over and above age. Specifically, CVS-negative scores significantly predicted Total Knowledge ($B = .59$; $sr^2 = .03$; $p = .002$), Understanding Connections among Problem Situations, Thoughts, Feelings and Behaviors (B = .17, sr^2 = .04; p = .001), Generating and Connecting Problem Situations, Feelings, and Behaviors (B = .33, sr^2 = .03; p = .004), and Understanding Healthy Thoughts Related to Problem Situations (B = .12, sr^2 = .05, p<.001). The other scientific reasoning scores did not significantly predict post-teaching KnoTS scores (see Table 4).

Does level of scientific reasoning predict retained learning of therapeutic skills after one week? Do scientific reasoning levels improve the prediction of retained learning, over and above age? Linear regression analyses were conducted in the same manner described above, with follow-up knowledge (KnoTS.4) as the dependent variable. The pattern of results was the same for analyses that did and did not control for age. As such, only the analyses controlling for age are reported. Again, more advanced scientific reasoning significantly predicted greater retained learning, over and above age. Specifically, EUT Total scores significantly predicted General Knowledge at follow-up (B = .07; sr^2 = .04; p = .002), and CVS-negative scores significantly predicted Understanding Connections among Problem Situations, Thoughts, Feelings, and Behaviors scores at follow-up (B = .12; sr^2 = .04; p = .004). The models testing the other indices of scientific reasoning as predictors of other retained knowledge scores were not significant (see Table 5).

Table 4. Scientific Reasoning Subscales Predict KnoTS Scores Post-Teaching, Controlling for Age, IQ, and Baseline KnoTS Scores

Scientific Reasoning	**Outcome Variable**	**Overall Model Fit**			**Baseline KnoTS**		**Age**		**IQ**		**Scientific Reasoning Scale**	
Scale	**KnoTS Scale**	**F(4,208)**	**R^2**	**Adj. R^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**
EUT Total	1	23.15***	.31	.30	.60***	.22	.47**	.03	.01	<.001	-.01	<.001
	2	11.74***	.19	.17	.19~	.03	.21***	.06	.03***	.06	.03	.005
	3	4.50**	.08	.06	.30***	.06	.05	.01	-.003	.001	-.01	.001
	4	13.62***	.21	.19	.47***	.18	.15	.01	-.01	.001	-.01	<.001
	5	9.14***	.15	.13	.37***	.12	.02	.001	-.01	.01	.02	.01
	6	2.00	.04	.02	.19~	.03	.05	.01	-.001	<.001	-.01	.004
		F(4,208)	**R^2**	**Adj. R^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**
CVS-positive	1	23.76***	.31	.30	.59***	.22	.45**	.02	-.002	<.001	.25	.01
	2	11.73***	.19	.17	.20**	.03	.21***	.07	.03***	.07	.07	.004
	3	4.64***	.08	.06	.29***	.06	.05	.004	-.01	.003	.04	.003
	4	13.86***	.21	.20	.46***	.17	.14	.01	-.01	.003	.11	.003
	5	9.67***	.16	.14	.38***	.13	.02	.002	-.01	.01	.06	.02
	6	1.90	.04	.02	.18~	.03	.04	.01	-.003	.002	.03	.002
		F(4,208)	**R^2**	**Adj. R^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**
CVS-negative	1	26.67***	.34	.33	.56***	.19	.44**	.02	-.01	<.001	.59**	.03
	2	11.88***	.19	.17	.19~	.03	.22***	.07	.03***	.07	.08	.01
	3	7.27***	.12	.11	.26***	.05	.04	.003	-.01	.01	.17***	.04
	4	16.30***	.24	.22	.43***	.15	.13	.01	-.02	.01	.33**	.03
	5	12.64***	.20	.18	.37***	.13	.01	.001	-.01	.01	.12***	.05
	6	2.78~	.05	.03	.18~	.02	.03	.004	-.004	.003	.08~	.02

Note. Coefficients reported are from the second step of each model, when scientific reasoning was added. ~$p \leq .05$, **$p \leq .008$, ***$p \leq .001$. EUT= Epistemological Understanding Task; CVS = Control of Variables Strategy; Outcome variables: 1 = Total Knowledge; 2 = General Knowledge; 3 = Understanding Connections among Problem Situations, Thoughts, Feelings and Behaviors; 4 = Generating and Connecting Problem Situations, Feelings and Behaviors; 5 = Understanding Healthy Thoughts Related to Problem Situations; 6 = Connecting Own Problem Situation and Feeling. Each row represents a separate analysis (see Example Table in Appendix A).

Table 5. Scientific Reasoning Subscales Predict KnoTS Scores at Follow-Up, Controlling for Age, IQ, and Baseline KnoTS Scores

Scientific Reasoning	**Outcome Variable**	**Overall Model Fit**			**Baseline KnoTS**		**Age**		**IQ**		**Scientific Reasoning Scale**	
Scale	**KnoTS Scale**	**F(4,208)**	**R^2**	**Adj. R^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**
EUT Total	1	16.52***	.24	.23	.38***	.14	.25	.01	.04	.01	.05	.002
	2	10.17***	.16	.15	.09	.01	.09	.01	.03***	.04	.07**	.04
	3	5.46***	.10	.08	.24***	.06	.07~	.02	.004	.003	-.003	<.001
	4	8.35***	.14	.12	.30***	.10	.16	.01	.01	.001	-.003	<.001
	5	6.80***	.12	.10	.23***	.09	.03	.01	<.001	<.001	.01	.002
	6	.87	.02	-.002	.06	.004	-.01	<.001	.01	.01	-.01	.001
		F(4,208)	**R^2**	**Adj. R^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**
CVS-positive	1	16.46***	.24	.23	.38***	.15	.27~	.01	.04~	.02	.10	,001
	2	7.49***	.13	.11	.11	.01	.12~	.02	.03***	.08	.01	<.001
	3	5.87***	.10	.08	.23***	.06	.07	.01	.003	.001	.05	.01
	4	8.37***	.14	.12	.30***	.10	.16	.01	.004	<.001	.03	<.001
	5	7.01***	.12	.10	.24***	.09	.03	.01	<.001	<.001	.03	.01
	6	1.14	.02	.003	.06	.004	-.01	.001	.01	.01	.04	.01
		F(4,208)	**R^2**	**Adj. R^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**
CVS-negative	1	18.10***	.26	.24	.36***	.13	.26	.01	.04~	.01	.36~	.02
	2	7.76***	.13	.11	.11	.01	.11~	.02	.03***	.08	.06	.004
	3	7.78***	.13	.11	.21***	.05	.07	.01	.002	<.001	.12**	.04
	4	10.30***	.17	.15	.27***	.08	.15	.01	<.001	<.001	.26~	.03
	5	8.21***	.14	.12	.23***	.09	.03	.01	-.001	<.001	.06~	.02
	6	1.10	.02	.002	.06	.004	-.01	.001	.01	.01	.03	.01

Note. Coefficients reported are from the second step of each model, when scientific reasoning was added. ~$p \leq .05$, **$p \leq .008$, ***$p \leq .001$. EUT= Epistemological Understanding Task; CVS = Control of Variables Strategy; Outcome variables: 1 = Total Knowledge; 2 = General Knowledge; 3 = Understanding Connections among Problem Situations, Thoughts, Feelings and Behaviors; 4 = Generating and Connecting Problem Situations, Feelings and Behaviors; 5 = Understanding Healthy Thoughts Related to Problem Situations; 6 = Connecting Own Problem Situation and Feeling. Each row represents a separate analysis (see Example Table in Appendix A).

Secondary Questions

Does abstract reasoning as measured with the WISC-IV Matrix Reasoning subtest predict learning immediately post teaching and at the one-week follow-up? We conducted linear regression analyses in the same manner described above, with matrix reasoning as the independent variable. Matrix reasoning did not significantly predict KnoTS scores at post-teaching or follow-up (see Table 6).

Relations among scientific reasoning, knowledge of therapeutic skills, and symptoms of psychopathology. ***Are level of scientific reasoning and baseline knowledge of CT skills related?*** We conducted partial correlations between scientific reasoning scales and KnoTS scales, controlling for age and IQ. As hypothesized, more advanced scientific reasoning was significantly associated with greater knowledge of therapeutic skills. Controlling for age and IQ, EUT Total and CVS-negative each significantly correlated with T1 KnoTS Total score ($r = .17$, $p = .01$; $r = .19$, $p = .007$, respectively) and Generating and Connecting Problem Situations, Feelings and Behaviors scores ($r = .14$, $p = .04$; $r = .19$, $p = .007$, respectively). EUT Total significantly correlated with KnoTS Understanding Connections scores ($r = .15$, $p = .03$).

Is baseline knowledge of therapeutic skills related to symptoms of psychopathology? We ran partial correlations, controlling for age and IQ. Consistent with our hypothesis, less knowledge of therapeutic skills was associated with more symptoms of psychopathology. Specifically, higher KnoTS.1 Total scores ($r = -.17$, $p = .01$) and higher KnoTS.1 Understanding Connections scores ($r = -.20$, $p = .004$) significantly correlated with lower scores on the CDI. Higher scores on the KnoTS Generating and Connecting Problem Situations, Feelings, and Behaviors scale significantly correlated with lower scores on CDI ($r= -.21$; $p=.002$), YSR Total Problems ($r = -.14$, $p = .05$), and Anxiety Problems ($r = -.14$, $p = .05$).

Is level of scientific reasoning related to symptoms of psychopathology? Significant partial correlations, controlling for age and IQ, indicated that more advanced scientific reasoning was associated with higher symptoms of psychopathology. Specifically, EUT Total significantly correlated with SCARED Total scores ($r = .14$; $p = .05$) as well as YSR Externalizing Problems ($r = .17$; $p = .02$). See Table A2 in Appendix A for all partial correlations among scientific reasoning, knowledge, and psychopathology variables.

Moderation. ***Does scientific reasoning moderate the relation between homework performance and retained learning of therapeutic skills?*** Linear regression analyses were conducted with age, IQ, and baseline KnoTS scores entered as covariates in the first step and scientific reasoning and homework performance entered as main effects. Individual's homework performance scores were calculated by summing the coded responses on completed homework. The two-way interaction between scientific reasoning and homework performance was entered in the second step. Simple slope analyses were conducted on all significant interactions, per Aiken and West (1991).

The interaction between EUT Total and homework performance significantly predicted General Knowledge scores at follow-up. In addition, the interactions between each CVS subscale (i.e., CVS-positive and CVS-negative) and homework performance significantly predicted Connecting Own Problem Situation and Feeling score (see Table 7). Simple slope analyses for all significant interactions revealed that for individuals low in scientific reasoning, better homework performance predicted significant increases in KnoTS scores (Figures 2, 3, and 4: bars A vs. B), whereas for individuals high in scientific reasoning, homework performance did not predict follow-up scores (Figure 2, 3, and 4: bars C vs. D). Also, for individuals who were low on homework performance, higher levels of scientific reasoning predicted significant increases in KnoTS scores (Figures 2, 3, and 4: bars A vs. C), whereas for individuals high on homework performance, level of scientific reasoning was not significantly related to scores at follow-up (Figure 2, 3, and 4: bars B vs. D). See Table 8 for a summary of the simple slope analyses.

Does abstract (i.e., matrix) reasoning moderate the relation between homework performance and retained learning of therapeutic skills? Linear regression analyses were conducted in the same manner described above, with matrix reasoning (rather than the scientific reasoning subscales) entered as a main effect in the first step, and the two-way interaction between matrix reasoning and homework performance entered in the second step. The matrix reasoning by homework performance interaction significantly predicted Connecting own Problem Situation and Feeling score at follow-up (see Table 9). Results of the simple slope analyses were the same as those found for scientific reasoning (see Table 8). That is, for individuals low in abstract (i.e., matrix) reasoning, better homework performance predicted significant increases in KnoTS scores (Figure 5: bars A vs. B), whereas for individuals high on abstract reasoning, homework performance did not predict follow-up scores (Figure 5: bars C vs. D). Also, for individuals who were low on homework performance, higher levels of abstract reasoning predicted significant increases in KnoTS scores (Figures 5: bars A vs. C), whereas for individuals high on homework performance, level of abstract reasoning was not significantly related to scores at follow-up (Figure 5: bars B vs. D).

Table 6. Abstract (i.e., Matrix) Reasoning Predicts Post-Teaching and Follow-Up KnoTS Scores, Controlling for Age, IQ, and Baseline KnoTS Scores.

Outcome Variable	Overall Model Fit			Baseline KnoTS		Age		IQ		Matrix Reasoning	
Post-Teaching											
KnoTS Scale	**F(4,208)**	**R^2**	**Adj. R^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**
Total Knowledge	24.73***	.32	.31	.60***	.22	.54***	.03	-.02	.002	.27~	.01
General Knowledge	12.12***	.19	.17	.19~	.03	.14***	.08	.03***	.04	.06	.01
Understanding Connections among Problem Situations, Thoughts, Feelings, and Behaviors	4.64***	.08	.06	.29***	.06	.06	.01	-.01	.004	.03	.003
Generating and Connecting Problem Situations, Feelings and Behaviors	13.90***	.21	.20	.47***	.18	.17	.01	-.02	.01	.08	.004
Understanding Healthy Thoughts Related to Problem Situations	9.17***	.15	.13	.37***	.13	.03	.01	-.01	.01	.03	.01
Connecting Own Problem Situation and Feeling	1.85	.03	.02	.18~	.02	.04	.01	-.004	.002	.01	.001
Follow-Up											
KnoTS Scale	**F(4,208)**	**R^2**	**Adj. R^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**
Total Knowledge	17.78***	.26	.24	.39***	.15	.33~	.02	.03	.01	.22~	.02
General Knowledge	9.38***	.15	.14	.11	.01	.14**	.03	.02**	.04	.10~	.03
Understanding Connections among Problem Situations, Thoughts, Feelings, and Behaviors	5.79***	.10	.08	.23***	.06	.08~	.02	.001	<.001	.03	.01
Generating and Connecting Problem Situations, Feelings and Behaviors	8.45***	.14	.12	.30***	.11	.17~	.02	.001	<.001	.04	.002
Understanding Healthy Thoughts Related to Problem Situations	7.57***	.13	.11	.23***	.09	.04	.01	-.002	.002	.03	.01
Connecting Own Problem Situation and Feeling	1.46	.03	.01	.06	.004	.001	<.001	.003	.002	.03	.01

Note. Coefficients reported are from the second step of each model, when matrix reasoning was added. ~$p \leq .05$; **$p \leq .008$; ***$p \leq .001$. Each row represents a separate analysis (see Example Table in Appendix A).

Table 7. Scientific Reasoning Subscales by Homework Performance Interactions Predict KnoTS Scores at Follow-up

Scientific Reasoning	**Outcome Variable**	**Overall Model Fit**			**Baseline KnoTS**		**Age**		**IQ**		**Scientific Reasoning Scale**		**HW Completion**		**Scientific Reasoning by HW Completion**	
Scale	**KnoTS Scale**	**F(4,208)**	**R^2**	**Adj. R^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**
EUT Total	1	10.47***	.30	.27	.40***	.13	.15	.01	.03	.01	-.01	<.001	.04~	.02	-.001	.001
	2	6.12***	.20	.17	.003	<.001	.06~	.01	.02	.02	.05**	.02	.02**	.05	-.004**	.04
	3	3.76**	.13	.10	.24**	.06	.05	.01	.01	.01	-.02	.01	.01	.02	<.001	<.001
	4	4.10***	.14	.11	.27***	.08	.15	.01	.01	.003	-.03	.003	.02	.01	.001	.001
	5	4.94***	.17	.13	.31***	.13	.01	.001	-.002	.001	.003	.001	.003	.004	.001	.01
	6	3.92***	.14	.10	.06	.004	-.02	.003	.01	.01	-.02	.01	.02***	.09	-.001	.01
		F(4,208)	**R^2**	**Adj. R^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**
CVS-positive	1	10.86***	.30	.28	.38***	.13	.14	.004	.03	.01	.15	.003	.04~	.03	-.01	.01
	2	4.06***	.14	.11	.04	.002	.07	.01	.02~	.03	.05	.004	.02**	.06	-.01	.01
	3	3.63**	.13	.09	.21***	.05	.04	.01	.003	.002	.04	.004	.01	.02	-.001	.001
	4	4.08***	.14	.11	.25***	.06	.14	.01	.01	.001	.05	.001	.02	.01	-.051	.003
	5	4.86***	.16	.13	.28***	.12	.01	.002	-.001	.001	.02	.003	.003	.01	-.001	.001
	6	5.43***	.18	.15	.07	.01	-.04	.01	.003	.002	.05	.01	.02***	.09	-.01**	.05
		F(4,208)	**R^2**	**Adj. R^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**	**B**	**sr^2**
CVS-negative	1	11.67***	.32	.29	.36***	.11	.12	.003	.02	.01	.31	.01	.04~	.02	-.02	.01
	2	4.19***	.14	.11	.05	.002	.06	.01	.02~	.03	.04	.002	.02**	.05	-.01	.01
	3	4.62***	.16	.12	.19~	.04	.03	.003	.002	.001	.10~	.03	.01	.02	-.003	.01
	4	4.60***	.16	.12	.23**	.05	.13	.01	.003	<.001	.21	.02	.02	.01	-.003	.001
	5	5.55***	.18	.15	.28***	.11	.01	.001	-.002	.002	.06~	.02	.002	.003	<.001	<.001
	6	5.19***	.17	.14	.06	.01	-.04	.01	.003	.002	.03	.01	.01***	.08	-.01**	.05

Note. Coefficients reported are from the second step of each model, when scientific reasoning was added. ~ = p ≤. 05, ** = p ≤ .008, *** = p ≤ .001. EUT= Epistemological Understanding Task; CVS = Control of Variables Strategy; Outcome variables: 1 = Total Knowledge; 2 = General Knowledge; 3 = Understanding Connections among Problem Situations, Thoughts, Feelings and Behaviors; 4 = Generating and Connecting Problem Situations, Feelings and Behaviors; 5 = Understanding Healthy Thoughts Related to Problem Situations; 6 = Connecting Own Problem Situation and Feeling. Each row represents a separate analysis (see Example Table in Appendix A).

Table 8. Scientific and Abstract Reasoning by Homework Performance Interactions: Simple Slopes Analyses

Bars in figures compared in each analysis		**A vs. B**	**C vs. D**	**A vs. C**	**B vs. D**	
High/Low Interaction Term		**Reasoning Low**	**Reasoning High**	**Homework Low**	**Homework High**	
Predictor Interaction Term		**Homework**	**Homework**	**Reasoning**	**Reasoning**	
Reasoning Variable	Outcome Variable/ KnoTS Scale	B	B	B	B	Figure
EUT Total	2	.04***	.003	.10***	-.01	2
CVS-positive	6	.03***	.01	.15**	-.06	3
CVS-negative	6	.02***	.004	.13**	-.07	4
Matrix Reasoning	6	.03***	.01	.10**	-.01	5

Note. Each cell represents the B and significance value for the predictor variable of interest in a single simple slope analysis. Each row represents all 4 simple slope analyses for a significant interaction between the reasoning variable and homework performance predicting the outcome variable. ** = p<.008; *** = p<.001. Outcome variables: 2 = General Knowledge; 6 = Connecting Own Problem Situation and Feeling

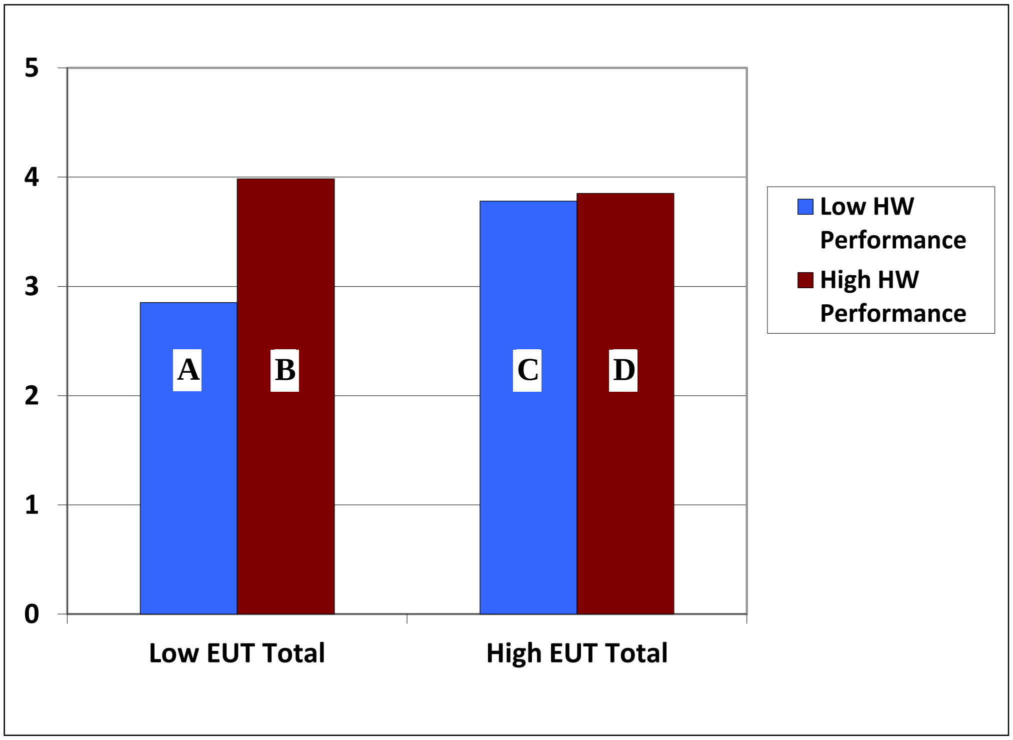

Figure 2. EUT total by homework performance predicting general knowledge score at follow-up

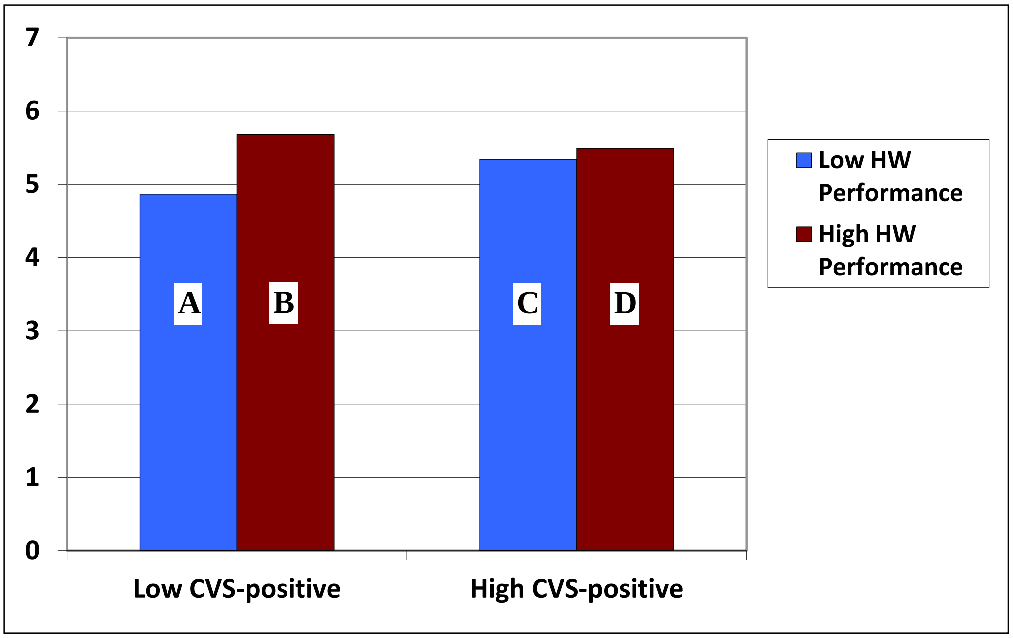

Figure 3. CVS-positive by homework performance predicting connecting own problem situation and feeling scores at follow-up.

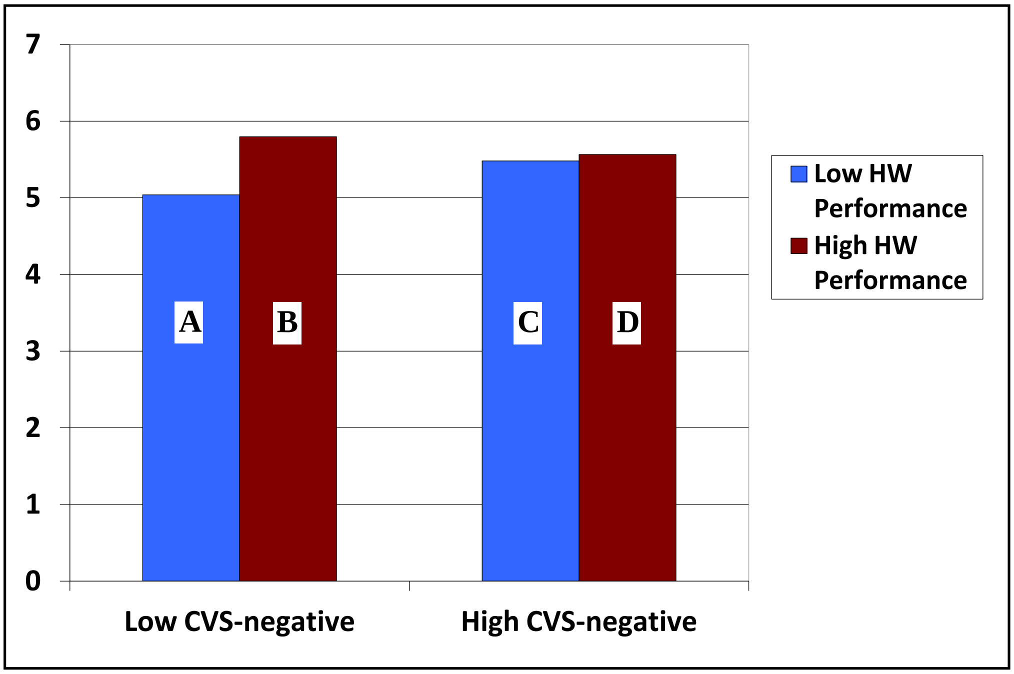

Figure 4. CVS-negative by homework performance predicting connecting own problem situation and feeling scores at follow-up.

Table 9. Abstract (i.e., Matrix) Reasoning by Homework Performance Interaction Predicts KnoTS Scores at Follow-Up

Outcome Variable	Overall Model Fit			Baseline KnoTS		Age		IQ		Matrix Reasoning		HW		Matrix Reasoning by HW	
	F(4,208)	R^2	Adj. R^2	B	sr^2	B	sr^2	B	sr^2	B	sr^2	B	sr^2	B	sr^2
1	10.87***	.30	.28	.40***	.15	.17	.01	.02	.002	.47	.01	.05~	.03	-.01	.004
2	3.95***	.14	.10	.05	.002	.08	.01	.02	.02	.11	.003	.02**	.06	-.001	.001
3	3.61**	.13	.09	.23**	.06	.04	.01	.003	.001	.10	.01	.01	.02	-.001	.004
4	4.00***	.14	.10	.26***	.07	.14	.01	.01	.002	.08	<.001	.02	.01	-.001	.001
5	5.26***	.18	.14	.28***	.12	.02	.01	-.004	.004	.08	.01	.003	.01	-.001	.003
6	5.34***	.18	.14	.09	.01	-.02	.003	<.001	<.001	.26**	.05	.02***	.11	-.004**	.04

Note. Coefficients reported are from the second step of each model, when matrix reasoning was added. ~p ≤ .05, **p ≤ .008, ***p ≤ .001. Outcome variables: 1 = Total Knowledge; 2 = General Knowledge; 3 = Understanding Connections among Problem Situations, Thoughts, Feelings and Behaviors; 4 = Generating and Connecting Problem Situations, Feelings and Behaviors; 5 = Understanding Healthy Thoughts Related to Problem Situations; 6 = Connecting Own Problem Situation and Feeling. Each row represents a separate analysis (see Example Table in Appendix A).

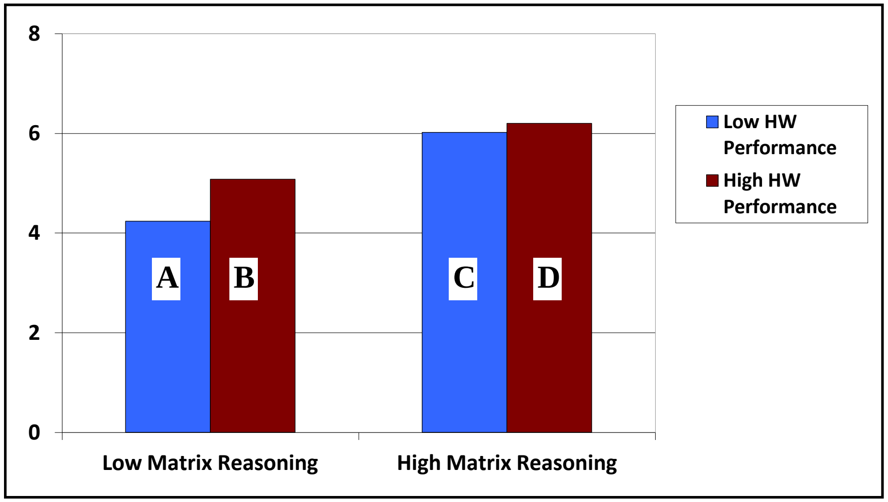

Figure 5. Matrix reasoning by homework performance predicting connecting own problem situation and feeling score at follow-up.

CHAPTER IV

DISCUSSION

The current study examined the relations among scientific reasoning, age, and learning of therapeutic skills used in cognitive therapy. As hypothesized, scientific reasoning significantly predicted children's ability to learn CT skills, with more advanced reasoning associated with greater learning immediately post-teaching and one week later. This relation was unique to scientific reasoning and was not found for abstract reasoning. In addition, scientific reasoning significantly moderated the relation between homework performance and retention of learning of CT skills. Abstract reasoning also significantly moderated the relation between homework performance and learning.

Primary Questions

More advanced scientific reasoning was related to significant increases in knowledge of CT skills immediately after the teaching session. Specifically, children's understanding of the control of variables strategy for negative outcomes (CVS-negative) significantly predicted their total knowledge of CT skills, ability to generate and understand connections among problem situations, thoughts, feelings, and behaviors, and their ability to understand healthy thoughts in the context of problem situations. Children's level of scientific reasoning as indexed by their CVS-negative score also predicted their understanding of connections among problem situations, thoughts, feelings, and behaviors one week later. In addition, children's epistemological understanding significantly predicted increases in general knowledge of CT skills assessed at follow-up.

An essential difference between this study and previous research examining the effects of development on therapeutic outcomes (Durlak, et al., 1991) was the actual measurement of cognitive development (i.e., scientific reasoning) separate from age. In the current study, correlations between age and scientific reasoning ability ranged from .06 to .12 and were not significant. This finding is consistent with previous research suggesting that age may be a poor proxy for cognitive development (Holmbeck & Kendall, 1991; Sauter, et al., 2009) and highlights the importance of examining these constructs separately in order to understand children's ability to learn CT skills. In the current study, all relations between scientific reasoning and learning remained significant when controlling for children's age, indicating that scientific reasoning incremented the prediction of learning, over and above the variance accounted for by age.

Although CVS-positive and CVS-negative were moderately correlated ($r = .57$; $p < .001$), CVS-negative predicted learning of therapeutic skills at post-teaching and follow-up, whereas CVS-positive did not. When faced with a negative outcome, individuals are more likely to think about changing the one variable they believe caused the negative outcome, which corresponds to the CVS strategy. In contrast, when faced with a positive outcome, individuals typically focus on holding the variable they believe is responsible for the positive outcome constant, which results in more frequent use of the "changing all but one variable" strategy. Thus, use of the CVS strategy with positive outcomes represents more advanced reasoning ability than understanding of CVS-negative. Most CT skills focus on dealing with problems – situations with negative outcomes – and therefore, CVS-negative may be more relevant than CVS-positive to the kinds of situations discussed and the types of skills taught in cognitive therapy. Consistent with evidence that understanding of CVS-negative typically develops prior to understanding of CVS-positive (Tschirgi, 1980), fewer children in the current sample had reached more advanced levels of CVS-positive understanding (25% of participants) than CVS-negative understanding (50% of participants). As such, it is also possible that the current study was under-powered to detect significant predictive effects for CVS-positive.

Children's epistemological understanding predicted general knowledge of therapeutic skills at follow-up. The multiple choice questions in the general knowledge subscale assessed children's understanding of the thinking process, as well as their knowledge about how one can gather evidence about thoughts through behavioral experiments and asking questions. Children with more advanced understanding of the reasoning process and the distinction between theory and evidence performed better on these questions. Epistemological understanding, however, did not predict children's ability to apply these concepts by generating or drawing connections among their own problem situations, thoughts, feelings, and behaviors. One possible explanation for this finding is that KnoTS items tapping application of cognitive skills did not ask children specifically to examine evidence when engaging in cognitive restructuring. Thus, this part of the KnoTS may not have tapped into children's understanding of the distinction between theory and evidence, which likely is an important aspect of restructuring thoughts through evidence examination.

Another possible explanation is that the measure of epistemological understanding used here did not assess aspects of development most relevant to therapy. Previous research indicates that epistemological understanding develops differently across various domains (Kuhn, et al., 2000). For example, children's epistemological understanding is more advanced when engaging in reasoning about scientific constructs than about social constructs. Kuhn and colleagues (2008) found that children used more absolutist explanations for social problems, whereas they used more multiplist and evaluativist explanations for scientific problems. The theories involved in scientific reasoning in traditional science vary greatly from those involved in everyday thinking, which are supported more by context and affect than empirical facts. Everyday topics may be easier to think about, as they are familiar and more concrete, but the affect associated with these cognitions may interfere with the use of accurate reasoning skills (Kuhn et al., 1995). Measures that tap into children's understanding of the distinction between theory and evidence specifically in social contexts may better predict their ability to learn and apply CT skills to personal problems and interpersonal contexts.

Secondary Questions

Abstract Reasoning. Abstract reasoning as measured by the WISC-IV matrix reasoning subscale did not predict children's learning of therapeutic skills at post-teaching or follow-up. Ability to engage in CT skills likely is more directly related to aspects of scientific reasoning than to a more general measure of abstract reasoning (Harrington, et al., 1998). The matrix reasoning subtest measures children's non-verbal pattern completion, analogical reasoning, and serial reasoning (Sattler, 2008). In contrast, CVS, a scientific reasoning measure, assesses the ability to reason about modifying variables to affect outcomes, which is more directly related to the CT skill of understanding that changing thoughts or behaviors may impact feelings. Thus, measuring specific types of reasoning that are most relevant to CT strategies likely will be more relevant for determining a child's readiness for CT than assessing general abstract reasoning abilities.

Relations among scientific reasoning, knowledge of therapeutic skills, and symptoms of psychopathology. As hypothesized, greater knowledge of CT skills was associated with fewer symptoms of psychopathology. Specifically, more knowledge was related to fewer depressive symptoms on the CDI, as well as less anxiety and fewer total problems on the YSR. Thus, children with symptoms of psychopathology have less knowledge of the cognitive skills addressed in CT, at least at the time they are having symptoms. Experiencing psychopathology may disrupt the normative course of developing these skills. Alternately, poorer understanding of CT skills (e.g., lack of cognitive restructuring ability) may contribute to the likelihood of experiencing psychopathology (Abela & Hankin, 2011). Given the cross-sectional nature of these data, the direction of this relation cannot be determined from the current findings. Future longitudinal research on the relation between knowledge of CT skills and psychopathology is needed to clarify the direction of this relation. Perhaps improving children's knowledge of CT skills could help to decrease or even prevent symptoms of psychopathology from developing in the first place.

Also consistent with our hypothesis, more advanced scientific reasoning was associated with greater knowledge of therapeutic skills. Specifically, better epistemological understanding and better understanding of CVS-negative were both associated with greater knowledge of CT skills at baseline. Thus, knowledge of the kinds of cognitive skills taught in CT (e.g., cognitive restructuring) may develop in parallel with other aspects of cognitive development.

In addition, we explored the relation between scientific reasoning and symptoms of psychopathology. More advanced epistemological understanding was associated with greater anxiety and externalizing problems. Certain aspects of cognitive development in adolescence (e.g., imaginary audience, personal fable; Lapsley, 1991) have been associated with risk for both internalizing disorders and engagement in risk-taking behaviors (Vartanian, 2000). Youth who have reached more advanced stages of reasoning also may be more likely to engage in egocentric thinking, which may result in either increased rumination or more rule-breaking behaviors.

The relation between more advanced epistemological understanding and greater externalizing problems also may be a function of the types of questions on the EUT. Children received higher scores if they demonstrated an understanding that there may be multiple reasons why an individual might lie or commit crimes. Individuals who demonstrate this understanding also may be more comfortable endorsing items related to rule-breaking behavior and other externalizing symptoms assessed on the YSR.

Moderation. Finally, we examined whether reasoning moderated the relation between homework performance and retention of learning. Homework is an essential element of any CT intervention, as it allows children to practice and master new skills through the implementation of CT skills in real world situations (Gaynor, et al., 2006; Simons, et al., 2012). Moreover, the quality of homework completion has been shown to predict therapy outcomes (Kazantzis, et al., 2005; Thase & Callan, 2006). We hypothesized that individuals who were less cognitively developed would be less likely to experience this benefit from homework, much in the same way that they might have difficulty learning CT skills. Epistemological understanding moderated the relation between homework performance and retention of general knowledge of CT skills at the follow-up. In addition, children's understanding of CVS-negative and CVS-positive, as well as children's abstract reasoning ability, all moderated the relation between homework performance and understanding the connection between one's own problem situation and feelings. Thus, the relation between homework performance and learning of CT skills varied as a function of multiple types of reasoning.

For individuals with more advanced reasoning, homework performance was not related to retained learning. In contrast, for children who were less advanced in reasoning, better homework performance significantly predicted retention of learning of CT skills. Better reasoning ability also predicted greater retained learning for youth who performed less well on the homework. The relation between reasoning ability and retained knowledge was not significant for those participants who performed well on the homework.

Thus, children with more advanced reasoning skills may be better able to learn and understand CT concepts regardless of homework performance. For children who are less cognitively developed, however, effectively doing the homework may facilitate their learning of the CT skills and bring them to the same level as those with higher cognitive development. Many CBT programs for youth have recommended abandoning cognitive techniques in favor of more behavioral interventions for those individuals who are less cognitively advanced (Harrington, 2005; Siqueland, et al., 2005; Stallard, 2009). The current findings suggest that less cognitively advanced children may be capable of learning cognitive skills if they adequately practice these skills between sessions.

Limitations and Future Directions

Limitations of the current study highlight important directions for future research. First, this study only examined one aspect of cognitive development – reasoning. Although there is strong evidence to suggest that scientific reasoning is particularly relevant to engaging effectively in CT, other types of reasoning (e.g., causal reasoning) as well as other aspects of cognitive (e.g., metacognition), social (e.g., perspective-taking), and emotional (e.g., feelings identification) development likely also will be important for understanding how children learn

CT skills (Grave & Blissett, 2004). In addition, the current study examined each scientific reasoning variable and each KnoTS subscale separately in order to understand unique relations among different aspects of scientific reasoning and the various CT skills. Future research combining multiple aspects of development into a single model, and determining which of these developmental skills are most predictive of children's ability to learn therapeutic skills, will be particularly informative for clinicians attempting to do cognitive therapy with children.

Second, the current study was conducted with typically developing children in a community sample. In addition, the CT skills were taught during a one-time 90-minute teaching session, as opposed to over the course of several weekly sessions. To make the current study more consistent with typical CT practices, homework was assigned and children's retention of knowledge one-week after the teaching session was examined. It is possible, however, that the relation between scientific reasoning and learning of CT skills is different in a clinical sample and when the CT skills are conveyed in the context of ongoing weekly therapy sessions. Future research is needed to examine the relations between cognitive development and the learning of CT skills by a treatment sample in an actual therapeutic setting.

The current study created and piloted a measure of knowledge of CT skills (i.e., the KnoTS). Randomized controlled trials of CT for depression in children and adolescents typically measure therapy outcomes through change in symptoms (e.g.,Kennard et al., 2009). No studies to date have assessed children's knowledge of the therapeutic skills taught in CT to determine whether improvement in knowledge or use of these skills partially accounts for therapeutic outcomes. In the current study, different KnoTS scales were uniquely related to specific aspects of scientific reasoning. Thus, the KnoTS measured multiple aspects of children's knowledge, including general questions about cognitive therapy skills and application of these skills to one's own problems.

The comparison of the two groups that completed the KnoTS measures before and after either a teaching session or an assessment session revealed greater changes in knowledge following the teaching session. These results indicate that the KnoTS measured both initial knowledge of CT skills and change in knowledge following specific instruction. The changes in KnoTS scores were small, however. In addition, the KnoTS has not been validated and tested in other settings and with other populations. Exploratory factor analysis showed three factors of the KnoTS coded items, but these factors need to be confirmed in other samples. Thus, further research on this measure is needed to establish its effectiveness for measuring children's knowledge of CT skills.

Finally, although the current results indicated that scientific reasoning predicted learning of CT skills, effect sizes were small. Scientific reasoning accounted for 3 to 5% of the variance in models in which it was a significant predictor. Notably, the overall models accounted for between 8 and 34% of the variance, with age only accounting for between 2 and 8%. Thus, the amount of variance predicted by scientific reasoning was small, but comparable to that predicted by age, and represents a significant portion of the overall variance accounted for by the full model. Small effect sizes likely were due in part to limitations of the KnoTS measure as well as the inclusion of only one aspect of cognitive development in each model. Further research is needed to establish the most valid measures of therapeutic knowledge in relation to multiple aspects of development.

Implications

At least two paths for making treatments more developmentally appropriate are possible: (a) modify the treatment to fit the developmental level of either the individual child or a certain developmental profile (Weisz & Weersing, 1999), or (b) enhance the children's developmental competencies to prepare them for learning more advanced therapeutic skills (Holmbeck & Kendall, 1991). To date, most treatment modifications have involved altering activities to be more or less complex, concrete, behavioral, cognitive, or visual (Sauter, et al., 2009; Stallard, 2002) based on informal evaluations of development using the age of the child.

Several studies have shown improvement in scientific reasoning skills through training, and some forms of training (e.g., practice in use of experimental space; schema induction) have been found to be more successful than others (e.g., general lessons on experimental strategies; Chinn & Malhotra, 2002; Klahr & Nigam, 2004; Siegler & Liebert, 1975). For example, studies have shown that CVS can be taught effectively (Chen & Klahr, 1999; Klahr & Nigam, 2004). Appropriate use of the strategy, however, does not necessarily generalize to other contexts following these interventions (Chen & Klahr, 1999). Scientific thinking also improves with repeated exposure to tasks (Kuhn, et al., 1995; Kuhn & Phelps, 1982; Kuhn, et al., 1992; Schauble, 1996) possibly through the impact on meta-level processes such as epistemological understanding (Kuhn, 2002). The finding that higher level of scientific reasoning development was associated with greater learning of therapeutic skills suggests that incorporating interventions focused directly on improving children's scientific reasoning abilities could, in turn, facilitate the subsequent mastery of cognitive therapy skills (Holmbeck, et al., 2006; Sauter, et al., 2009; Shirk, 1999).

In summary, the current study demonstrated that cognitive development, specifically scientific reasoning, predicted children's ability to learn skills taught in cognitive therapy, over and above age. In addition, children with lower reasoning ability reached similar levels of learning as those with higher reasoning ability after engaging in effective practice of CT skills for homework. Thus, clinicians may benefit from measuring children's reasoning ability before engaging in cognitive therapy exercises to determine how a specific child is likely to respond to CT, and how much support and additional practice may be needed to help the child learn these skills. Future research should examine other areas of development that are related to children's understanding of therapeutic skills in order to further improve the efficacy of CT with children.

APPENDIX A

CORRELATION TABLES AND EXAMPLE TABLE

Table A1. Means, Standard Deviations, and Correlations among All Variables

	Mean	SD	1	2	3	4	5	6	7	8	9
1. Age	12.84	1.91	1								
2. Gender	.41	.49	-.032	1							
3. IQ	106.42	12.98	-.224**	-.119	1						
4. Matrix Reasoning	11.19	2.74	-.297***	.048	.491***	1					
5. Total Knowledge	40.51	4.58	.185**	.162*	.215**	.066	1				
6. General Knowledge	5.05	1.37	.119	.083	.158*	.052	.504***	1			
7. Understanding Connections	6.44	1.20	.187**	.117	.130	.053	.842***	.210**	1		
8. Generating and Connecting PS, Feelings and Behaviors	14.95	2.84	.140*	.123	.142*	.049	.864***	.195**	.848***	1	
9. Understanding Healthy Thoughts Connected to PS	5.62	.85	.135*	.133*	.176*	.048	.633***	.180**	.587***	.505***	1
10. Connecting own PS and Feeling	5.39	.81	.008	.137*	-.024	-.008	.364***	.128	.378***	.156*	.080
11. EUT Total	12.40	4.41	.115	-.015	.327***	.121	.236***	.152*	.190**	.197**	.143*
12. CVS-positive	1.76	1.59	.071	-.089	.195**	.209**	.107	.017	.060	.187**	-.021
13. CVS-negative	2.51	1.59	.063	.096	.164*	.150*	.227**	.119	.163*	.227**	.061
14. CDI Total	7.77	5.62	-.021	.107	.103	.044	-.138*	.012	-.185**	-.130	.047
15. SCARED Total	20.33	11.58	-.110	.220**	.132	.094	.034	.052	.023	-.064	.062
16. YSR Anxious/Depressed	4.69	3.98	.032	.227**	.209**	.155*	.024	.072	.002	-.039	-.030
17. YSR Withdrawn/Depressed	3.21	2.24	-.022	.089	.120	.044	.004	.056	.005	-.049	.047
18. YSR Somatic Complaints	4.12	3.49	-.126	.172**	-.049	-.034	-.037	-.021	-.030	-.106	.105
19. YSR Internalizing Problems	12.03	8.01	-.045	.213**	.115	.074	-.003	.042	-.011	-.079	.044
20. YSR Externalizing Problems	9.90	6.52	.275***	.007	-.055	-.120	.006	.051	.025	-.037	.044
21. YSR Total Problems	42.30	21.32	.084	.112	.084	-.009	-.047	.038	-.046	-.109	.033
22. YSR Affective Problems	4.04	3.34	-.039	.112	.115	-.010	-.044	.027	-.047	-.054	.044
23. YSR Anxiety Problems	2.40	2.22	.006	.177**	.169*	.110	-.008	.051	-.025	-.081	-.031
24. YSR Somatic Problems	2.63	2.60	-.138*	.128	-.120	-.058	-.071	-.061	-.055	-.120	.064
25. Homework Performance	61.90	15.07	-.019	.169*	.132	.061	.263**	.222**	.194*	.157	.063

Note. *p<.05; **p<.01; ***p<.001; Values provided are for 225 participants included in analyses. PS = Problem Situation; CVS = Control of Variables Strategy; EUT = Epistemological Understanding Task

Table A1 (Continued). Means, Standard Deviations, and Correlations among All Variables

	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
10. Connecting own PS and feeling	1														
11. EUT Total	.016	1													
12. CVS-positive	.011	.041	1												
13. CVS-negative	.051	.051	.593***	1											
14. CDI Total	-.068	-.064	.056	.036	1										
15. SCARED Total	.046	.152*	-.060	.024	.437***	1									
16. YSR Anxious/Depressed	.002	.128	.019	.106	.536***	.749***	1								
17. YSR Withdrawn/ Depressed	.037	.087	.038	.085	.485***	.586***	.570***	1							
18. YSR Somatic Complaints	-.010	.016	-.028	.052	.431***	.609***	.492***	.464***	1						
19. YSR Internalizing Problems	.007	.095	.008	.099	.590***	.800***	.871***	.765***	.810***	1					
20. YSR Externalizing Problems	-.037	.158*	.046	.134*	.385***	.308***	.376***	.260***	.346***	.410***	1				
21. YSR Total Problems	-.044	.148*	.032	.114	.629***	.688***	.764***	.626***	.690***	.855***	.753***	1			
22. YSR Affective Problems	.004	.118	.031	.064	.650***	.554***	.659***	.672***	.636***	.793***	.471***	.796***	1		
23. YSR Anxiety Problems	-.047	.122	-.033	.092	.388***	.708***	.857***	.491***	.455***	.762***	.283***	.636***	.465***	1	
24. YSR Somatic Problems	-.041	-.026	-.040	.034	.336***	.559***	.410***	.383***	.948***	.724***	.321***	.612***	.494***	.405***	1
25. Homework Performance	.155	.088	-.049	.084	-.155	-.053	-.019	-.091	-.121	-.085	-.103	-.133	-.154	-.046	-.131

Note. *p<.05; **p<.01; ***p<.001; Values provided are for 225 participants included in analyses. PS = Problem Situation; CVS = Control of Variables Strategy; EUT = Epistemological Understanding Task

Each row of Tables 4, 5, 6, 7, and 9 represents a separate analysis. The Example Table below shows the data included in the first row of Table A2.

Example Table. EUT Total Score predicts KnoTS Total Score at Post-Teaching.

Predictor	B	sr^2
Baseline KnoTS	.60***	.22
Age	.47**	.03
IQ	.01	<.001
EUT Total Score	.01	<.001

Note. F (4,208) = 23.15, R^2 = .31, Adjusted R^2 = .30.

Table A2. Partial Correlations among KnoTS Subscales, Scientific Reasoning, and Psychopathology

	1	2	3	4	5	6	7	8	9	10	11
1. Total Knowledge	1										
2. General Knowledge	.447***	1									
3. Understanding Connections	.812***	.124	1								
4. Generating and Connecting Problem Situations, Feelings and Behaviors	.846***	.136*	.828***	1							
5. Understanding Healthy Thoughts Connected to Problem Situations	.565***	.055	.552***	.433***	1						
6. Connecting own Problem Situation and Feeling	.369***	.122	.356***	.124	.078	1					
7. EUT Total	.169*	.105	.150*	.141*	.043	.046	1				
8. CVS-positive	.059	-.051	.019	.130	-.049	-.017	-.045	1			
9. CVS-negative	.185**	.075	.120	.185**	-.005	.050	-.007	.568***	1		
10. CDI Total	-.173*	-.040	-.199**	-.209**	-.100	.064	-.110	.030	.009	1	
11. SCARED Total	-.003	-.025	.032	-.033	.014	.089	.137*	-.097	.003	.425***	1
12. YSR Anxious/Depressed	-.083	-.037	-.062	-.095	-.061	-.018	.056	-.050	.049	.522***	.749***
13. YSR Withdrawn/Depressed	-.027	-.007	.009	-.048	-.016	.064	.072	.013	.063	.481***	.575***
14. YSR Somatic Complaints	-.003	-.029	.011	-.040	.007	.105	.066	-.010	.071	.422***	.623***
15. YSR Internalizing Problems	-.049	-.032	-.022	-.077	-.031	.056	.076	-.025	.072	.572***	.795***
16. YSR Externalizing Problems	-.084	-.045	-.040	-.078	-.089	.061	.167*	.015	.113	.379***	.338***
17. YSR Total Problems	-.116	-.053	-.080	-.138*	-.079	.056	.125	-.012	.076	.613***	.703***
18. YSR Affective Problems	-.049	-.030	-.020	-.063	-.009	.075	.099	.004	.045	.633***	.541***
19. YSR Anxiety Problems	-.128	-.047	-.097	-.137*	-.116	-.022	.080	-.108	.034	.379***	.699***
20. YSR Somatic Problems	-.034	-.056	-.017	-.043	-.017	.058	.050	-.012	.066	.338***	.587***

Note. *p<.05; **p<.01; ***p<.001; CVS = Control of Variables Strategy; EUT = Epistemological Understanding Task

Table A2 (Continued). Partial Correlations among KnoTS Subscales, Scientific Reasoning, and Psychopathology

	12	13	14	15	16	17	18	19	20
12. YSR Anxious/Depressed	1								
13. YSR Withdrawn/Depressed	.559***	1							
14. YSR Somatic Complaints	.533***	.487***	1						
15. YSR Internalizing Problems	.873***	.765***	.832***	1					
16. YSR Externalizing Problems	.346***	.265***	.390***	.412***	1				
17. YSR Total Problems	.751***	.631***	.730***	.859***	.749***	1			
18. YSR Affective Problems	.649***	.669***	.654***	.787***	.483***	.795***	1		
19. YSR Anxiety Problems	.851***	.476***	.495***	.761***	.254***	.627***	.457***	1	
20. YSR Somatic Problems	.471***	.421***	.950***	.761***	.367***	.667***	.525***	.455***	1

Note. *p<.05; **p<.01; ***p<.001; CVS = Control of Variables Strategy; EUT = Epistemological Understanding Task

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