Exploring Relations Between Memory and Internalizing and Externalizing Behaviors in

Childhood

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Abstract

There is a growing field of research which suggests internalizing and externalizing disorders cause disruptions in cognitive functioning, including memory. This association has primarily been explored in adults. This honors thesis explores the potential connection between mnemonic discrimination as a measure of episodic memory and internalizing and externalizing behaviors in young children. Researchers collected data on memory using a Mnemonic Similarity Task (MST) in children between 3 and 5 years of age and related their performance to ratings of their internalizing and externalizing behavior from the Child Behavior Checklist (CBCL) completed by a parent or guardian. Results did not support the hypothesis that internalizing and externalizing behaviors were related to poor episodic memory, as has been shown in adult populations. Future research with older children should be conducted in order to understand when during development that internalizing and externalizing behaviors begin to inhibit episodic memory.

Exploring Relations Between Memory and Internalizing and Externalizing

Behaviors in Childhood

Among adults, there is a well-established connection between psychopathology and memory performance. Higher levels of depression, anxiety, antisocial behaviors, and substance abuse have been associated with worse performance on a variety of memory tasks (Clark et al., 2009, Gould et al., 2007, Li et al., 2013, Sadeh et al., 2016). One important type of memory is episodic memory. Episodic memory is defined as the ability to recall specific details (where, when, and what) about past events (Clayton et al., 2007). Salient memories often include many overlapping features (a holiday dinner and a birthday party, for example, have many similar components) and it is important to be able to distinguish these features into unique events in order to encode distinct memories (Ngo et al., 2017). The computational process in the brain that enables individuals to distinguish between similar stimuli during encoding is referred to as pattern separation (Canada et al., 2018). Researchers have begun to explore this at the behavioral level using mnemonic discrimination tasks which require individuals to discriminate two similar items from memory and is thought to engage pattern separation. While poor mnemonic discrimination has already been linked to greater internalizing psychopathology in adults (Bernstein et al., 2020; Dohm-Henson et al., 2020), it remains unknown whether this association is present in childhood. Enhancing understanding of the association between memory performance and child psychopathology is important to developmental and clinical psychology: implications for whether this tendency begins in childhood or later on may be important in identifying appropriate interventions for children exhibiting internalizing and externalizing behaviors.

Theoretically, both internalizing and externalizing symptoms can influence memory performance on mnemonic discrimination tasks. Considering internalizing distress, such as anxiety and depression, some have theorized that overgeneralizing fear or rigid depressogenic thinking patterns can lead to poor distinction between encoded events (Bernstein et al., 2020). Indeed, several studies have documented the relation between mnemonic discrimination and internalizing symptoms or behaviors in adult populations (Bernstein et al., 2020; Dohm-Henson et al., 2020). This overgeneralization of fear or negative stimuli becomes maladaptive—for example, it is adaptive after one is burned on a hot stove to avoid touching a stove top, and even to generalize this fear to other hot surfaces. It becomes maladaptive when one is unable to cook at a stove or in a kitchen out of overgeneralized fear (Bernstein et al, 2020). Alternatively, theoretically, externalizing symptoms such as difficulties with concentration, impulsivity, or antisocial behaviors may challenge an individual's ability to attend to appropriate details while forming episodic memories (Fabbro & Crescentini, 2018, Krauel et al., 2007). This is consistent with existing literature linking higher levels of externalizing behaviors in children and adults with poor episodic memory, when broadly defined (Felton et al 1987, Oie and Rund 1999, Krauel et al., 2007, Quinlan & Brown 2003, Rhodes et al 2005). The association between mnemonic discrimination as a specific measure of episodic memory and externalizing psychopathology among child populations remains unknown. Other measures of episodic memory, however, have provided evidence that episodic memory may be impaired in children, adolescents, and adults with ADHD (Felton et al 1987, Oie and Rund 1999, Krauel 2007, Quinlan & Brown 2003, Rhodes et al 2005). This impairment may be tied to difficulty for those with attention deficits to cope with complex encoding scenarios (August 1987, Krauel et al. 2007). Impairments in episodic memory have also been found in children and adults presenting

antisocial behaviors linked with conduct disorder, antisocial personality disorder, and borderline personality disorder (Fertuck et al. 2006a; 2006b; Holmqvist 2008; Krauel et al. 2007; Quinlan & Brown 2003). Studying mnemonic discrimination as a specific measure of episodic memory may provide clarity regarding what mechanism of episodic memory is disrupted by internalizing or externalizing behaviors.

Traditional literature exploring the relation between memory and psychopathology in adults has used DSM diagnoses or the prevalence of disorder-specific symptoms in non-clinical populations. DSM diagnoses rely on participants meeting a selected number of symptoms to qualify for a specific, individual diagnosis (Krueger & Markon, 2006). A difficulty with this model is that most people, particularly children, who meet diagnostic criteria for one disorder will also meet criteria for multiple disorders. This is referred to as comorbidity and is considered the norm amongst clinical and research populations. In fact, all common dimensions of psychopathology in children are correlated (Lahey et al., 2011). Nevertheless, most psychological researchers have preferred to instead conceptualize psychological issues as being independent, distinct categories (Caspi & Moffitt, 2018). This theoretical framing downplays the significant overlap between psychopathologies in favor of neatly and falsely operationalizing research variables, inhibiting progress on identifying mechanisms and consequences of various symptomological features (Latzman et al., 2020). An alternate framing of the issue is that most mental illnesses are caused by a few underlying liabilities and manifest themselves in several overarching domains of disordered thoughts and behavior: internalizing, externalizing, and psychotic domains (Caspi & Moffitt, 2018, Krueger & Markon, 2006, Lahey et al., 2011). Therefore, in the present study we assess a broad conceptualization of internalizing and

externalizing behaviors. This study did not investigate psychotic domains as the typical onset of psychotic problems does not occur until early adulthood (McGorry et al., 2011).

There are several major developmental changes in episodic memory between childhood and adulthood. Research has found that early childhood is a time when one's ability to form detailed memories and discriminate between them is improving at a rapid rate (Canada et al., 2018, Canada et al., 2020; Riggins, 2014). These major changes mean that it cannot simply be assumed that relations between episodic memory and internalizing and externalizing behaviors are the same in childhood as they are in adulthood. Identifying whether similar relations between internalizing and externalizing behaviors and episodic memory exist in childhood as do in adulthood may provide insight to the development of episodic memory and appropriate times to stage interventions.

The current study sought to address this gap between studies on psychopathology and memory in adults versus children. Capitalizing upon an ongoing study on memory development in young children, we examined performance on the Mnemonic Similarity Task (MST) and related it to parent-reported internalizing and externalizing behaviors from the Child Behavior Checklist (the gold-standard assessment of behavioral symptoms in children). We hypothesized that internalizing and externalizing behaviors would be negatively correlated with performance on the mnemonic discrimination task, indicating poor episodic memory. Lure discrimination indices were calculated from children's performance on the MST and examined in relation to children's internalizing and externalizing behaviors via linear regression analyses. While results indicate that the relation between children's memory and psychopathology was not significant, they justify further studies examining children of multiple ages to determine when this relation appears during development.

Method

Participants

A total of 18 children participated in the current study. Of these children, one was excluded due to a response bias during the task. The final sample consisted of 17 children (N(female)=11, M(age)=3.86, SD(age) =0.72, range = 3.13-5.92 years). When asked to select the race of their child (they could select more than one category) 11 identified as White or Caucasian, three as Black or African American, two as Asian, one as Native Hawaiian or Pacific Islander, one as American Indian or Alaskan Native, and one did not wish to answer. Children were recruited from a major metropolitan area through an online research database of families interested in participating in developmental research managed by the University of Maryland, College Park, as well as via electronic mailing lists, social media, and word of mouth. Children were participating in a larger study examining the relation between memory and nap behavior. Participants were screened in order to ensure they were typically developing, born full-term, and heard English at least 50% of the time. Informed consent was obtained from parents.

Mnemonic Similarity Task (MST)

Children completed the child-friendly version of the MST designed by Ngo et al. (2017) via Zoom video conferencing. The task includes 66 pairs of common everyday objects and 33 novel objects. Each object-pair consists of a target item (item shown during encoding) and a lure item (a highly similar item). The children were required to differentiate between items shown during encoding (targets), highly similar items (lures), and novel items (foils). An example of these stimuli is presented in Figure 1. The object-pairs and novel items are divided so that children were equally as likely to be shown targets, lures, or foils during the test.

Figure 1
Example of target (first seen at encoding), lure, and foil stimuli.

| Target | Lure | Foil |

The MST included an incidental encoding phase, training phase, and test (if training threshold was passed). Children first completed an incidental encoding phase where they were shown the target items and asked to identify whether each item belongs inside or outside. Children then underwent a brief training for the retrieval, where they completed a mock version of the task where they were shown examples of targets and asked to discriminate between the example targets, highly similar images (example lures) and novel images (example foils). Then children completed the MST during the testing phase. The number of correct responses to target, lures and foils was recorded by the experimenter via button press.

The percent of target images correctly accepted (target hits), and the percent of foils falsely accepted (foil false alarms) was calculated to ensure that participants were able to understand the overall task.

In addition, a lure discrimination index was calculated to index pattern separation. This is calculated based on the formula shown below, which measures the difference in performance between targets and lures.

$$(\% \; Correct \; Target \; Memory) - (\% \; Incorrectly \; Recognized \; Lures)$$

Equation 1: Calculating the lure discrimination index

Possible scores on this index range from -1 to +1, with positive scores indicating successful discrimination between targets and lures, negative scores indicating a likelihood to overgeneralize similar items, and a score of zero indicating chance-level discrimination.

Lure discrimination indices were calculated from the subject's performance on the MST during their first time completing the task for the larger study.

One child was excluded because of response bias. The child accepted all targets, lures and foils as being seen during the encoding period, indicating that they may not have understood the goal of the task or did not attend during the encoding period.

Child Behavior Checklist (CBCL)

Parents of the children completed the Child Behavior Checklist (CBCL), one of the general assessment tools included in the Achenbach System of Empirically Based Assessment (ASEBA) to evaluate behavioral-emotional problems in children (Achenbach & Edelbrock, 1991). A version of the tool exists for 18-month to five-year-old's to be filled out by a parent or guardian. The CBCL is designed for typically developing children and reflects internalizing and externalizing behaviors rather than diagnoses of specific disorders. A secure link for the CBCL was sent to parents via Qualtrics shortly after their child completed the memory task.

The independent variables of interest were the total score for internalizing problems and the total score for externalizing problems in the CBCL data. The CBCL consists of 99 questions about a variety of problem behaviors. The questions were scored on individual 3-point Likert scales. The subscale for internalizing behaviors includes 36 questions about emotionally reactive behaviors, anxious and depressed behaviors, somatic complaints and withdrawn behaviors. The subscale for externalizing behaviors includes 24 questions about attention problems and aggressive behaviors. The total internalizing behavior and externalizing behavior scores range

from 0 to +2, with 0 representing an absence of problem behavior and +2 representing the highest possible amount of problem behavior as reflected by the questionnaire. Performance on the CBCL internalizing and externalizing subscales was somewhat lower than the CBCL normative scores.

Results

Prior to data collection, significance level was set at 0.05 and outliers were defined as being three standard deviations above or below the mean. There were no outliers in the final data set. Of the 17 children included in the study, two children did not have complete CBCL data, as their parent(s) declined to answer some questions. These two children had their internalizing and externalizing scores calculated based on the questions the parent(s) completed. There were no significant sex differences on any of the measures in the study (see Table 1). Some exploratory analyses were conducted on the component parts of the MST in addition to the lure discrimination indices. Results indicated that relations between these components and internalizing and externalizing behaviors were not significant (see Appendix).

Participants varied on their performance on the MST with lure discrimination indices ranging from -0.27 to 0.73 ($M = 0.16$, $SD = 0.22$). There was also variation in the internalizing behavior scores, which ranged from 0 to 0.58 ($M = 0.15$, $SD = 0.17$) and the externalizing behavior scores, which ranged from 0 to 1 ($M = 0.29$, $SD = 0.31$). Raw scores for the internalizing and externalizing subscales were somewhat lower than normative raw scores (see Table 2). It is possible that the limited sample or overall high SES of the group contributed to lower CBCL scores.

To explore relations between internalizing behavior and lure discrimination index, a linear regression was conducted. Results indicated the model was not significant ($R^2 = 0.06$,

$F(1,15) = 0.97$, $p = 0.34$) (see Table 3 and Figure 2). Internalizing behavior was not a significant predictor of performance on the mnemonic discrimination task.

A linear regression was also conducted to determine relations between externalizing behavior and lure discrimination index. Results indicated the model was not significant (R^2 =0.04, $F(1,15) = 0.58$, $p = 0.46$) (see Table 4 and Figure 3). Externalizing behavior was not a significant predictor of performance on the mnemonic discrimination task.

Table 1

Results of Welch Two Sample t-tests to determine sex differences in the data

Logistic parameter	Females		Males		t	df	p
	M	*SD*	*M*	*SD*			
Lure Discrimination Index	0.21	0.24	0.07	0.08	1.68	14.98	0.11
Targets Hit	0.81	0.2	0.77	0.15	0.45	13.34	0.66
Foil False Alarms	0.15	0.24	0.26	0.25	-0.87	9.85	0.41
Internalizing Behavior Scores	0.18	0.19	0.07	0.09	1.79	15.98	0.09*
Externalizing Behavior Scores	0.37	0.34	0.14	0.13	2.06	15.52	0.06*

Note. Mean parameter values for each of the analyses are shown for females ($n = 11$) and males ($n = 6$), as well as the results of Welch two sample *t*-tests comparing the parameter estimates between the sexes. * indicates p < 0.1, ** indicates p < 0.05, *** indicates p < 0.01.

Table 2

Mean and Standard Deviation for Study Subscale Raw Scores and CBCL Subscale Normative Raw Scores

CBCL Subscales	Study Scores	CBCL Norm

	M	SD	M	SD
Emotionally Reactive	1.8	2	2.4	2.2
Anxious Depressed	1.8	2	2.9	2.3
Somatic Complaints	1.2	1.9	1.8	1.9
Withdrawn	0.7	1.2	1.5	1.7
Attention Problems	1.2	1.7	2.5	1.9
Aggressive Behavior	5.5	5.9	10.4	6.4
Internalizing Behavior	5.5	5.9	8.6	6.2
Externalizing Behavior	6.7	7	12.9	7.7

Note. Mean and standard deviations are shown for study raw scores ($N = 17$) and CBCL

normative raw scores ($N = 700$).

Table 3

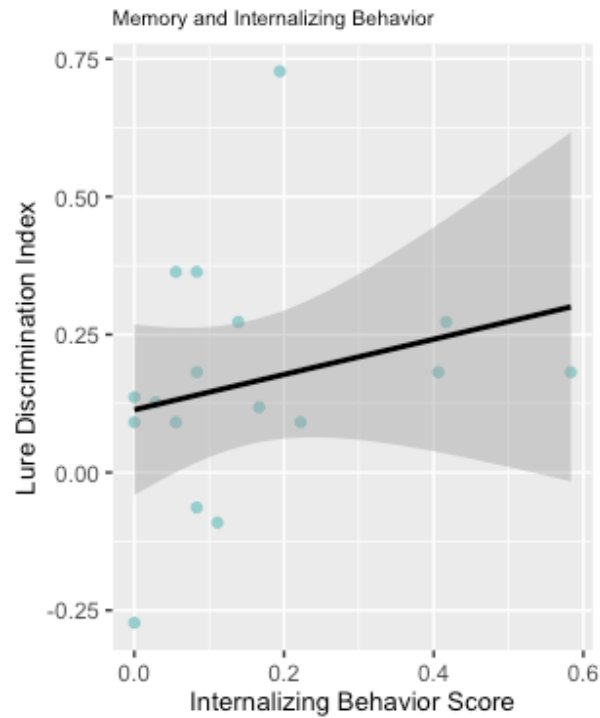*Regression Analysis Summary for Internalizing Behavior Predicting Lure Discrimination Index*

Effect	Estimate	SE	95% CI		p
			LL	UL	
Variable					
Intercept	0.114	0.073	--	--	0.138
Internalizing Behavior Score	0.32	0.324	-0.371	1.012	0.339

Note. $N = 17$. CI = confidence interval; LL = lower limit; UL = upper limit. * indicates $p < 0.1$,

** indicates $p < 0.05$, *** indicates $p < 0.01$.

Figure 2

Results of linear regression analysis examining relations between internalizing behavior scores

and performance on mnemonic discrimination task as measured by the lure discrimination index.

Table 4

Regression Analysis Summary for Externalizing Behavior Predicting Lure Discrimination Index

Effect	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Variable					
Intercept	0.125	0.073	--	--	0.111
Externalizing Behavior Score	0.134	0.177	-0.242	0.511	0.459

Note. *N* = 17. CI = confidence interval; *LL* = lower limit; *UL* = upper limit. * indicates p < 0.1,

** indicates p < 0.05, *** indicates p < 0.01.

Figure 3

Linear regression analysis for externalizing behavior score and performance on mnemonic

discrimination task as measured by the lure discrimination index.
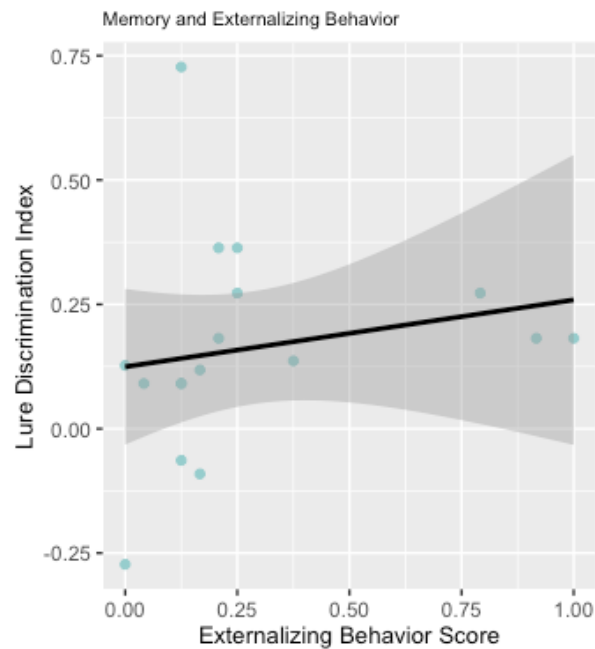
Discussion

The purpose of this honors thesis was to explore possible relations between performance

on a mnemonic discrimination task and internalizing and externalizing behaviors in children. As

discussed in the introduction, previous research has linked internalizing behaviors (such as

depression and anxiety symptomology) to decreased performance on the MST in clinical and

non-clinical adult populations (Bernstein et al., 2020; Dohm-Henson et al., 2020). Mnemonic

discrimination has not previously been studied in relation to externalizing behaviors, but other

measures of episodic memory have linked externalizing behaviors such as attention deficit and

antisocial behaviors to poor episodic memory in both children and adults (Felton et al 1987, Oie

and Rund 1999, Krauel et al., 2007, Quinlan & Brown 2003, Rhodes et al 2005). Therefore, it

was hypothesized that children with higher internalizing and externalizing behavior scores would perform worse on the mnemonic discrimination task, indicating poor episodic memory.

Results of this study did not support the hypothesis; there were no significant relations between performance on the MST and either internalizing or externalizing behaviors. There are several possible explanations for a lack of significant findings. First, the current study had a fairly small sample size ($N = 17$), and thus may not have had adequate power to detect the hypothesized effect. The effect that this thesis investigates may be a relatively small one—therefore, having a small sample size reduces the power and increases the margin of error, making it difficult to determine if an effect exists. Second, the MST task was designed to be administered in person, but due to restrictions caused by the COVID-19 pandemic, children in this study completed the MST over Zoom video conferencing. This may have contributed to children being distracted due to their environments. Third, because the CBCL relies on parent-reported behaviors, there could be a potential omitted variable bias, such as parents overcorrecting for their children's behavior. Alternatively, it is also possible there is no relation between internalizing and externalizing behaviors and mnemonic discrimination performance in childhood. This could indicate that the relation between psychopathology and episodic memory is markedly different in children and their adult counterparts. The participants in this study were preschool-aged children (M(age)=3.86, SD(age) =0.72). Children's episodic memory undergoes major developmental changes between the ages of 4 and 6 (Canada et al., 2020). The relation between psychopathology and episodic memory may appear later in childhood, in adolescence or in adulthood. This possibility could be explored in future research by investigating relations between internalizing and externalizing behaviors and mnemonic discrimination performance in children of multiple age groups.

Although this study addressed a novel question there are some limitations worth noting. First, the study was limited by its small sample size. A larger sample size would yield more power to detect effects and would allow also for the investigation of sex-related differences or other demographic differences. A second limitation was the non-diverse nature of the sample. Eleven of the 17 children included in the final sample identified as White or Caucasian. Limited racial diversity in our sample limits our ability to generalize the results to non-White or Caucasian populations. A more diverse sample would improve the external validity of the study.

In conclusion, although this study did not provide evidence of a significant relation between internalizing and externalizing behaviors in memory during childhood it does provide an insight into the potential developmental changes in episodic memory or psychopathology that makes this relation appear in adulthood. Future research should investigate children in the preschool age range as well as the elementary school age range, and adults, to determine when the relation between psychopathology and episodic memory develops. Better understanding of why this difference exists could contribute to clinical decisions on the optimal time for interventions.

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Appendix

Exploratory Analyses on Component Parts of MST

   This appendix consists of the regression summaries for the exploratory analyses performed on the component parts of the MST. These analyses were performed in order to gain understanding as to whether there was an indicator of episodic memory not fully reflected by the lure discrimination indices that had an association to internalizing and externalizing behaviors. As mentioned in the Results section of the paper, none of the performed analyses were significant.

Regression Analysis Summary for Internalizing Behavior Predicting Target Hits

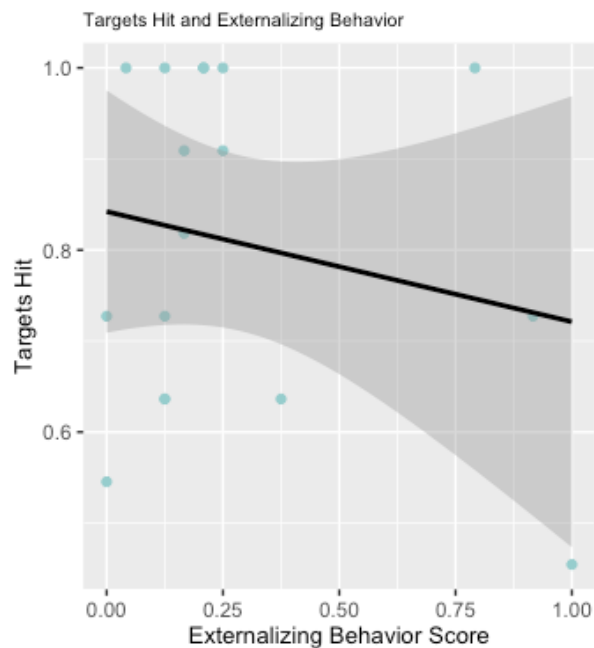| Effect	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Variable					
Intercept	0.82	0.06	--	--	1.49e-09***
Internalizing Behavior Score	-0.1	0.28	-0.71	0.5	0.72

Note. $N = 17$. CI = confidence interval; *LL* = lower limit; *UL* = upper limit. * indicates p < 0.1, ** indicates p < 0.05, *** indicates p < 0.01. Model was not significant ($R^2 = 0.01$, $F(1,15) = 0.13$, $p = 0.72$).
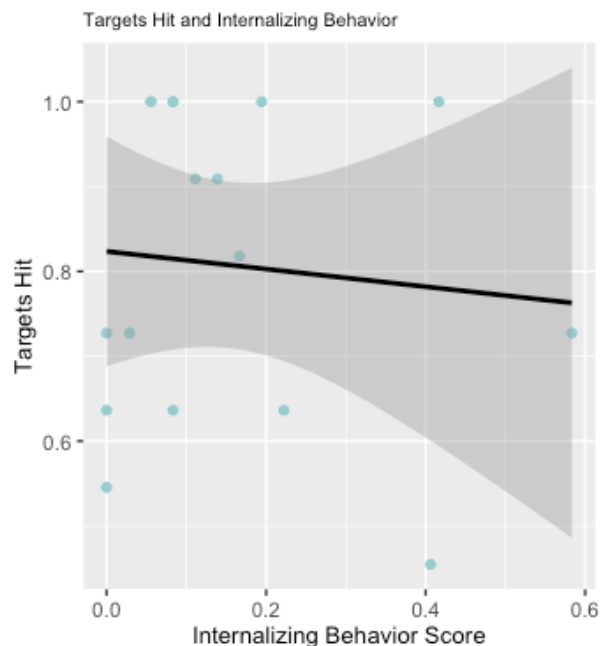
Targets Hit and Internalizing Behavior

Regression Analysis Summary for Externalizing Behavior Predicting Target Hits

Effect	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Variable					
Intercept	0.84	0.06	--	--	8.57e-10***
Externalizing Behavior Score	-0.12	0.15	-0.44	0.2	0.43

Note. $N = 17$. CI = confidence interval; *LL* = lower limit; *UL* = upper limit. * indicates p < 0.1, ** indicates p < 0.05, *** indicates p < 0.01. Model was not significant ($R^2 = 0.04$, $F(1,15) = 0.65$, $p = 0.43$).

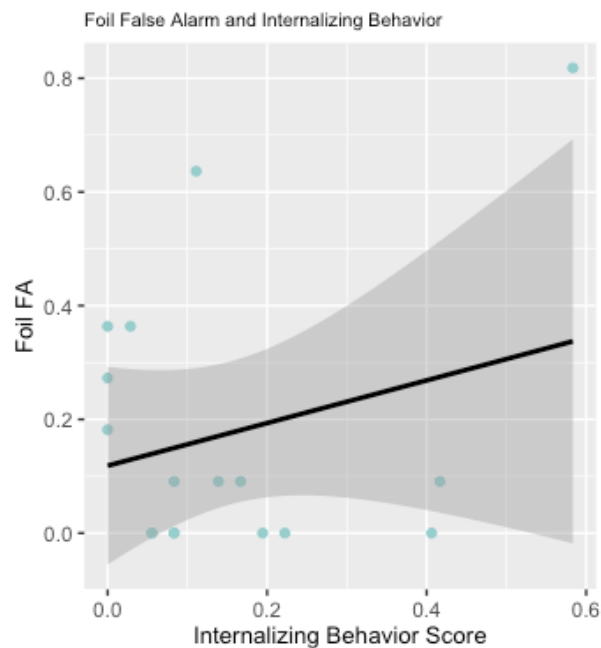Targets Hit and Externalizing Behavior

Regression Analysis Summary for Internalizing Behavior Predicting Foil False Alarms

Effect	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Variable					
Intercept	0.12	0.08	--	--	0.17
Internalizing Behavior Score	0.38	0.36	-0.4	1.15	0.32

Note. $N = 17$. CI = confidence interval; *LL* = lower limit; *UL* = upper limit. * indicates p < 0.1,

** indicates p < 0.05, *** indicates p < 0.01. Model was not significant ($R^2 = 0.07$, $F(1,15) =$

1.06, $p = 0.32$).

Foil False Alarm and Internalizing Behavior

Regression Analysis Summary for Internalizing Behavior Predicting Foil False Alarms

Effect	Estimate	SE	95% CI		p
			LL	UL	
Variable					
Intercept	0.12	0.08	--	--	0.15
Internalizing Behavior Score	0.18	0.2	0.24	0.6	0.37

Note. $N = 17$. CI = confidence interval; *LL* = lower limit; *UL* = upper limit. * indicates p < 0.1, ** indicates p < 0.05, *** indicates p < 0.01. Model was not significant ($R^2 = 0.05$, $F(1,15) = 0.87$, $p = 0.37$).

Foil False Alarm and Externalizing Behavior