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Predisposing Factors for Elevated Restricted and Repetitive Behavior in Typically Developing Toddlers

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Little is known about the relation between levels of restricted and repetitive behavior (RRB) in infants and parent factors. The present study investigated maternal and psychosocial factors (depressive symptoms, socio-economic status, social support) and mother–infant engagement factors (mind-mindedness, sensitivity, and infant–mother attachment security) as predictors of children's RRB at age 26 months in a sample of 206 mothers and children. Maternal depressive symptoms predicted levels of sensory and motor repetitive behavior and rigid, routinized, and ritualistic repetitive behavior. Lower socioeconomic status also predicted independent variance in children's sensory and motor repetitive behavior. The relations between maternal depressive symptoms and both types of RRB were not mediated through observational measures of maternal sensitivity or mind-mindedness at 8 months, or attachment security at 15 months. The results are discussed in terms of whether stress regulation, self-stimulation, and genetic susceptibility can help explain the observed link between maternal depressive symptoms and RRB in the child.

Restricted and repetitive behavior (RRB) is commonly seen in typically developing children (Cevikaslan, Evans, Dedeoglu, Kalaca, & Yazgan, 2014; Evans et al., 1997; Leekam et al., 2007). RRB can be divided into sensory and motor repetitive behavior (e.g., body rocking, mouthing, hand mannerisms) and rigidity, routinized, and ritualistic behavior (e.g., insisting that aspects of daily routine must remain the same, engaging in the same activity repeatedly). Both types of RRB appear to be healthy features

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of development in certain developmental periods, but endurance of RRB beyond adaptive periods can be associated with developmental delay or difficulty, and RRB features in the symptomatology of pervasive developmental disorders, learning disabilities, and anxiety disorders (Leekam, Prior, & Uljarević, 2011; Pietrefesa & Evans, 2007).

Within clinical research, attention has often been paid to the immediate or precipitating factors for RRB, and their posited function or purpose for the individual, usually with a view to reducing their expression or supporting the individual (Boyd, McDonough, & Bodfish, 2012; Graheme et al., 2015; Hall, Thorn, & Oliver, 2003; Tröster, 1994). However, it is also important to gain a clear understanding of the more enduring traits of the individual or environment that predispose a child to develop and maintain a repertoire of RRB. Elevated levels of RRBs can become entrenched in preschoolers with and without intellectual disability or pervasive developmental disorders, affecting children's ability to learn, and having detrimental effects on children and their caregivers (Berkson & Tupa, 2000; Berry, Russell, & Frost, 2018; Harris, Mahone, & Singer, 2008). Many of these extreme RRBs are thought to develop from initially adaptive RRB across the first two years of life (Leekam et al., 2011); therefore, understanding early predisposing factors for elevated or enduring patterns of RRB may support the provision of early intervention to prevent these behaviors becoming entrenched (Berkson & Tupa, 2000). The study reported here investigated whether aspects of the early caregiving environment predispose infants to display elevated levels of RRB, and whether ritualized behavior (e.g., insistence on routines) and motor and sensory behavior (e.g., body rocking, mouthing) share predisposing factors or show distinctive profiles, as suggested by research on typically developing children (Larkin, Meins, Centifanti, Fernyhough, & Leekam, 2017) and children with autism spectrum disorders (ASD) (Bishop, Richler, & Lord, 2006; Richler, Bishop, Kleinke, & Lord, 2007; Turner, 1999).

An important aspect of the early environment to consider is maternal characteristics, given that subclinical traits or deficits are common in parents of children with more marked manifestations of atypical development (see Moreno-De-Luca et al., 2015). The etiology of behavioral disorders is understood to involve the interaction of multiple environmental and genetic risk and protective factors (Pennington, 2006), and as such, maternal characteristics may link to child behavior through genetic and/or environmental means. Maternal depression, for example, is understood to have a negative impact on children's emotional, cognitive, and behavioral development, effected through both shared genetic risk and environmental factors (Mars et al., 2012; Natsuaki et al., 2010; Rice et al., 2017; Yan, Benner, Tucker-Drob, & Harden, 2017), balanced against protective factors (Collishaw et al., 2016). Children of depressed mothers have higher levels of psychopathology, behavioral, and social adjustment difficulties (Billings & Moos, 1983; Carter, Garrity-Rokous, Chazan-Cohen, Little, & Briggs-Gowan, 2001; Dietz, Jennings, Kelley, & Marshal, 2009; Goodman et al., 2011; Luoma et al., 2001; Murray & Cooper, 1997), as well as higher irritability, lower responsiveness, less engagement in social relationships, and a more limited range of affect (Carter et al., 2001). Maternal depression is also associated with children having difficulty with self-regulation in response to frustration and stress, and with disrupted sleep and eating routines (Landy, 2000). It is likely that the influence is bidirectional to some extent: For example, poor sleep patterns in infants are associated with heightened risk for maternal depression (Bayer, Hiscock, Hampton, & Wake, 2007; Dennis

& Ross, 2005). Depression is also associated with and predictive of higher life stressors, due to avoidant coping strategies, thus maternal depression may generate higher stress levels within families (Holahan, Moos, Holahan, Brennan, & Schutte, 2005). No study has yet examined the associations between measures of maternal depression or symptoms of depression and RRB in typical infant development, although they may be inter-related.

How might maternal depression be related to the development of RRB? One possible environmental factor associated with RRB is a lack of adequate levels of stimulation. In extreme cases, children who have been raised in poorly run institutions show heightened levels of RRB (Ames, 1997; Gesell, 1947; Spitz, 1945; Thelen, 1981; Tröster, 1994). In less extreme cases, Thelen (1980) proposed that infants who are held and "jiggled" less often by their parents are more likely to engage in sensory and motor behavior, such as rocking, in order to compensate for the lack of vestibular stimulation. Sensory and motor RRB is consistently found to be more likely in situations with low arousal, such as sitting alone (Berkson & Tupa, 2000; Teng, Woods, Twohig, & Marcks, 2002). Animal models also support this thesis. For example, in deer mice, lower levels of environmental stimulation are associated with higher levels of RRB, and environmental enrichment reduces their expression (Lewis, Tanimura, Lee, & Bodfish, 2007).

A meta-analysis of observational studies of infants and mothers with depression found that mothers with depression exhibited dampened reactions to their infants, with more negative and disengaged behavior (Lovejoy, Graczyk, O'Hare, & Neuman, 2000) and preoccupation in mothers with psychopathology is thought to mediate the negative effects on child development by reducing responsiveness to the environment (Stein, Lehtonen, Harvey, Nicol-Harper, & Craske, 2009). The social withdrawal and disengagement associated with depression is likely to mean that the infants will have less stimulation from and interaction with the mother, which may be compensated for through the infant engaging in RRB.

Depression is also known to be associated with sensory difficulties. Sensory defensiveness in healthy adults has been linked to higher levels of depression, which may arise from social withdrawal and avoidant coping strategies to avoid stimulation (Kinnealey & Fuiek, 1999). It is therefore possible that parental depression may be related to children's RRB through shared sensory sensitivity, or through altered parenting, such as avoidant coping in response to difficult child behavior. Avoidant coping strategies characteristic of depression (Holahan et al., 2005) may mean parents retreat from positively managing more difficult aspects of child behavior, which may lead to lower levels of engagement with children. The present study explored this possibility by investigating whether maternal depressive symptoms throughout the first two years of life predicted higher rates of RRB in 2-year-olds.

We also considered the role of so-called third-factor variables (Murray & Cooper, 1997), such as low socio-economic status (SES) and social support, which typically accompany maternal depression (Barker, Copeland, Maughan, Jaffee, & Uher, 2012). Households with low SES tend to have higher levels of stressors, and may also provide lower levels of cognitive stimulation for the infant, for example, through reduced book-reading and increased TV watching (Bradley & Corwyn, 2002; Evans, 2004). Parental depression is most likely to impact on children in the presence of these additional social variables (Barker et al., 2012; Billings & Moos, 1983; Carter et al., 2001). Therefore, SES may be associated with infant stress and lack of stimulation in the

environment, both of which may contribute to elevated levels of RRB. In order to investigate the contribution of these social–environmental factors to levels of RRB, the present study involved a socially and economically diverse sample of mothers and infants to enable us to examine SES and mothers' perceived social support as contributing factors to the expression of RRB in 26-month-olds.

The present study also investigated whether maternal depressive symptoms and variables relating to the social environment were directly or indirectly related to children's RRB. One obvious possibility is that these factors relate to children's RRB via their impact on the quality of mother–infant interaction. Thelen (1981) discussed how RRB may represent the infant's attempts to be noticed by the caregiver in order to have a need met, and reported comments by parents such as "That's his angry kick" or "That banging means she can't wait for the next spoonful of food" (p. 242) in response to their child's RRB. Rhythmic motor behavior in the first year is thought to support the development of communication (Iverson & Fagan, 2004), and moreover, parental responses to infants' non-verbal behavior support the onset of meaningful communication and language (Leezenbaum, Campbell, Butler, & Iverson, 2014). In keeping with a transactional model, the parent's responses to and interpretation of the infant's early communicative behavior imbues it with meaning which supports the infant to communicate independently (Sameroff, 2009; Tamis-LeMonda, Bornstein, & Baumwell, 2001; Vygotsky, 1978). As such, two possibilities arise: It is possible that high levels of RRB in infants may exhaust the parent's capacity to respond to these behaviors or see them as meaningful, or conversely, that RRB may be elevated when infants' communicative signals go unnoticed, perhaps due to caregivers not attending to or understanding their behavior. Therefore, the present study explored whether mothers' sensitivity or their tendency to interpret their babies' behavior as meaningful predicted lower rates of RRB.

This tendency to interpret the infant's behavior as meaningful and intentional can be conceptualized as parental mind-mindedness—the parent's attunement to their infant's internal states (Meins, Fernyhough, Fradley, & Tuckey, 2001; Meins et al., 2012). Parental mind-mindedness in the first year of life has been found to predict a range of relational and cognitive outcomes including attachment security, language ability, theory of mind, and behavioral functioning (Kirk et al., 2015; Laranjo, Bernier, & Meins, 2008; Laranjo, Bernier, Meins, & Carlson, 2010, 2014; Lundy, 2003; Meins, 2013; Meins et al., 2002; Meins, Muñoz-Centifanti, Fernyhough, & Fishburn, 2013; Meins, Fernyhough, Arnott, Leekam, & de Rosnay, 2013). There is some evidence that mothers with clinical levels of depression are less likely to comment appropriately on their infants' mental states compared with psychologically healthy mothers (Pawlby et al., 2010), and mothers with severe mental illness have been found to have lower levels of mind-mindedness compared with psychologically healthy controls (Schacht et al., 2017).

In addition, maternal depression has been shown to relate negatively to secure infant–mother attachment (Coyl, Roggman, & Newland, 2002; Martins & Gaffan, 2000), which in turn is thought to predict the infant's emotion regulation abilities (Kochanska, 2001). Securely attached infants demonstrate more mature self-regulation abilities (Cassidy, 1994; Waters et al., 2010) such as lower physiological stress responses in challenging situations (Nachmias, Gunnar, Mangelsdorf, Hornik Parritz, & Buss, 1996). One possibility therefore is that the infant may engage in RRB as a means of alleviating or regulating stress. The study reported here was the first to

investigate whether infant–mother attachment security predicted typically developing children's RRB. As well as investigating direct relations between children's RRB and the three measures of the quality of infant–mother interaction (sensitivity, mind-mindedness, and attachment security), we also explored whether these variables mediated any observed relation between children's RRB and maternal depressive symptoms or the social–environmental factors.

The evidence for distinct profiles of sensory and motor RRB and rigidity, routinized, and ritualistic RRB (Uljarević et al., 2017) led us to expect differences in the predisposing factors for these two subtypes. Current thinking is that sensory and motor RRB supports motor development in the first 2 years of life, but is less adaptive when elevated or sustained after this period. For example, sensory and motor RRB is common in typically developing infants, peaking in the first 12–15 months of life, before declining after age 2 (Arnott et al., 2010; Leekam et al., 2007). In contrast, rigidity, routinized, and ritualistic RRB starts to increase from age 2, peaking around age 4, and declining by age 6 (Cevikaslan et al., 2014; Evans et al., 1997). The present study assessed RRB when children were 26 months of age, an age at which higher levels specifically of sensory and motor RRB can be seen as less adaptive. In support of this proposal, Larkin et al. (2017) reported that sensory and motor RRB at 26 months was associated with poorer concurrent language and symbolic play skills, and predicted poorer language and theory of mind abilities at age 4, whereas levels of rigidity, routinized, and ritualistic RRB at the same age did not have any negative associations with developmental outcomes, appearing to still be adaptive within this developmental period. It therefore seems reasonable to propose that non-optimal social and environmental factors may relate to higher levels specifically of sensory and motor RRB at age 26 months. While Larkin et al. (2017) demonstrated the correlates and consequences of RRB, the study did not investigate predisposing factors for these behaviors. Understanding predisposing factors can improve our understanding of this developmental feature and its significance as a marker of potential psychopathology.

Using the same sample of children as Larkin et al. (2017), the present study investigated whether maternal depressive symptoms in the first year of the child's life predicted RRB in 2-year-olds, and whether this relation was mediated through infant–mother interaction. We hypothesized that higher levels of sensory and motor RRB would be predicted by higher maternal depressive symptoms, lower SES and perceived social support, lower maternal sensitivity and mind-mindedness, and insecure infant–mother attachment. We explored whether the infant–mother interaction variables mediated any observed relations between RRB and maternal depressive symptoms, SES, and perceived social support.

METHOD

Participants

A socially diverse sample of 206 (108 girls) infants and their mothers were recruited onto a longitudinal study of social and cognitive development, in the first year of life. To be included in the study, infants had to be born full term and mothers had to speak English with their infants at home, even if it was not their native language. Infants with any major health difficulties were excluded. Families' Hollingshead Index scores (Hollingshead, 1975) ranged from 11 to 66, and almost half of the sample

($n = 90$) came from the lowest two levels of this scale (no post-16 education, unemployed/unskilled–menial/semiskilled–manual occupation). The majority of participants were white ($n = 203$). The mean age for mothers entering the study was 28.08 years ($SD = 5.48$, Range 16–41). The sample was recruited through health professionals and community groups, and ethical approval was provided by both health service and University committees. At each testing phase, mothers gave full informed consent for themselves and their infants' participation. The guidance of the American Psychological Association and the British Psychological Society was followed for all testing procedures. Testing at all phases took place in the developmental laboratory at the University. One child from the sample went on to receive a diagnosis of ASD, described as a mild form of Asperger's syndrome. Excluding this child from the analyses did not impact on the results, and therefore, the child's data were retained.

At Phase 1, infants were 8 months of age ($M = 8.50$, $SD = 0.48$, Range = 7–10), at Phase 2, infants were aged 15 months ($M = 15.50$, $SD = 0.60$, Range = 13–17), and at Phase 3, infants were aged 26 months ($M = 26.04$, $SD = 0.86$, Range 24–28).

Materials

Maternal mind-mindedness

At Phase 1 (8 months), mothers were observed playing with their infants for 20 min. Mothers were instructed to play with their child as they would at home. These observations were transcribed verbatim, and the mother's speech was coded for mind-mindedness using previously operationalized criteria (Meins et al., 2001, 2012). The coding scheme identifies mind-related comments made by the mother which focus on the infant's mental states (e.g., thoughts, desires, preferences), mental processes (e.g., remembering, deciding), emotions, or attempts to influence others (e.g., teasing, joking). Comments where the mother speaks on behalf of the child were also coded as mind-related (e.g., "Can I eat this Mummy?"). These comments were then coded as either appropriate or non-attuned by viewing the filmed interactions. A mind-related comment was coded as appropriate where it (a) appeared to be an accurate depiction of the infant's behavior (e.g., "You want that rattle" as the infant looks toward or reaches for the rattle); (b) where the mother's comment linked the infant's internal state with a related past or future event, or (c) where the comment was designed to re-engage the infant after a lull in the interaction (e.g., "You'll like this one"). A mind-related comment was coded as non-attuned where (a) it did not appear to the coder to represent an accurate depiction of the infant's behavior (e.g., "You're bored of that teddy" as the infant continues to explore and manipulate the teddy), (b) it referred to a past or future event without any obvious link to the infant's current internal state, (c) the mother ignored the infant's current interest and engagement and asked what the infant wanted to do, or (d) the referent of the mother's comment was unclear.

All of the sessions were coded by a trained experimenter who was blind to all other measures and hypotheses, and a second trained, blind experimenter coded a randomly selected 25% of the sessions; raters achieved perfect agreement for identifying mind-related comments, and inter-rater reliability for coding mind-related comments dichotomously as appropriate or non-attuned was $\kappa = .70$ (87% agreement). Mothers received scores for appropriate and non-attuned mind-related comments expressed as a

percentage of the total number of comments produced during the session in order to control for differences in maternal verbosity.

Maternal sensitivity

The Phase 1 observations of mother–infant free play were coded for maternal sensitivity using Ainsworth, Bell, and Stayton's (1974) coding scheme, which assesses general maternal sensitivity according to a scale from 1 (highly insensitive) to 9 (highly sensitive). The coders were not involved in coding mind-mindedness and were blind to all other variables and to the study's hypotheses. The first coder coded all sessions and the second coded a randomly selected 25%; inter-rater reliability was ICC = .83.

Maternal mood and perceived social support

At Phases 1 and 2, mothers completed the Beck Depression Inventory, a well-standardized and validated 21-item questionnaire measure of mood (BDI: Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). Higher scores represent higher levels of depressive symptoms. At Phase 1, they also completed a 15-item questionnaire measure of perceived social support (Henderson, Duncan-Jones, McAuley, & Ritchie, 1978) which focuses on feelings of loneliness, isolation, and perceived social support. Responses are given on a 5-point Likert scale, with a possible overall range from 15 to 75, which higher scores indicating higher perceived social support.

Mother–infant attachment

At Phase 2, attachment security was assessed using the strange situation procedure (Ainsworth, Blehar, Waters, & Wall, 1978). All assessments were coded by a trained, reliable coder who was blind to all other measures and the study's hypotheses. A second reliable, blind researcher coded a randomly selected 25%; inter-rater reliability was κ = .82 on the four-way attachment classification system.

Repetitive behavior

At Phase 3, the Repetitive Behaviour Questionnaire-2 (RBQ-2; Leekam et al., 2007) was completed by mothers. This is a 20-item questionnaire was developed from the Repetitive Behaviour Interview (Turner, 1996) and the Diagnostic Interview for Social Communication Disorders (Wing, Leekam, Libby, Gould, & Larcombe, 2002) and has high internal consistency and good reliability (Arnott et al., 2010; Leekam et al., 2007). Parents are asked to rate the frequency or severity of their child's RRB over the past month, yielding scores on a 3-point scale for two subscales: (a) sensory and motor behaviors and (b) rigidity, routines, and restricted interests. Mean scores are calculated by adding up the frequency/severity scores (1–3) for each subscale and dividing by the number of items completed within that subscale. In keeping with previous research using the RBQ-2, only items 1–19 were scored, with items 7 and 12 omitted due to being statistically associated with both subscales.

Infant language

Infant language was included as a control measure given that previous studies have found an association between language ability and levels of RRB (Harrop, McConachie, Emsley, Leadbitter, & Green, 2014). At Phase 3, children's expressive and receptive language abilities were assessed using the Preschool Language Scales-3 (UK) (Boucher & Lewis, 1997). Standardized scores for total language (which combine both expressive and receptive abilities) were used in the analyses.

Planned analyses

Following descriptive statistics to characterize the sample, we planned to examine the relations between RRBs and the continuous variables (maternal depressive symptoms, perceived social support, SES, maternal sensitivity) using Pearson's correlations, and the categorical variable (attachment security) through ANOVA and t-tests. To test the longitudinal relation between maternal depressive symptoms and RRB and the potential mediating effects of social–environmental variables we planned to run two multiple regressions with sensory and motor RRB as the dependent variable in the first, and rigidity, routines, and restricted interests as the dependent variable in the second. A power analysis using G* Power software indicated that for a multiple linear regression with 7 predictors to detect a medium effect size (0.15) with power of 0.8 would require a sample size of $n = 103$, and therefore, the sample size of $n = 206$ was deemed more than adequate for these analyses.

RESULTS

Descriptive statistics and preliminary analyses

Incomplete or partial completion of certain measures meant that data were available for the following participants: 203 children completed the Preschool Language Scale; 199 mothers completed the BDI at Phase 1 and 198 at Phase 2; 194 mothers completed the perceived social support measure; 192 mothers completed the RBQ-2 at Phase 3. Mind-mindedness and sensitivity data were not available for one dyad due to a

TABLE 1
Descriptive Statistics for All Continuous Variables

	M	SD	Range
Appropriate MRC	5.34	3.64	0–18.67
Non-attuned MRC	1.58	1.88	0–8.94
Maternal sensitivity	5.64	1.48	2–9
Perceived social support	60.15	8.73	30–75
Maternal depression	15.63	13.00	0–81
Sensory and motor restricted and repetitive behavior	1.59	0.45	1–3
Rigidity, routines, restricted interests	1.55	0.41	1–2.88
Child language	93.79	16.87	62–133

Note. MRC = Mind-related comments, maternal depression combines 8- and 15-month data.

technical recording difficulty, and two strange situations were terminated due to undue child distress. Table 1 shows the descriptive statistics for all continuous variables.

Beck Depression Inventory scores at Phases 1 and 2 were highly positively correlated $r(189) = .74$, $p < .001$, and therefore, the scores were combined into one BDI score for the 198 participants who had completed the measure at both time-points. There was no gender difference on the rigidity, routines, and restricted interests subscale of the RBQ-2 (Girls $M = 1.52$, $SD = 0.40$, Boys $M = 1.58$, $SD = 0.42$), $t(190) = 1.09$, $p = .279$, $d = 0.15$, but there was a non-significant trend toward boys having higher scores on the sensory and motor behavior subscale (Girls $M = 1.53$, $SD = 0.40$, Boys $M = 1.64$, $SD = 0.48$), $t(190) = 1.66$, $p = .098$, $d = 0.25$. As shown in Table 2, children's concurrent language scores were negatively correlated with sensory and motor behavior scores, but were unrelated to rigidity, routines, and restricted interests scores (note that these two correlations were previously reported in Larkin et al. (2017)).

Relations between RRB and social–environmental variables

As shown in Table 2, sensory and motor behavior scores were positively correlated with maternal depressive symptoms, and negatively correlated with perceived social support, SES, and maternal sensitivity. The negative correlation between sensory and motor behaviors and appropriate mind-related comments was at trend level ($p = .090$). Rigidity, routines, and restricted interests scores were positively correlated with depressive symptoms and negatively correlated with perceived social support, but this subtype of RRB was unrelated to the infant–mother interaction variables.

In an exploratory analysis to further investigate the relation between maternal depressive symptoms and RRB, mothers with elevated scores on the BDI at both time-points (e.g., above the "normal" range, >13) were identified, which created a group of 15 "depressed" mothers (7.3%). Comparing this group of "depressed" mothers to the remaining mothers, it was found that both kinds of RRB were higher in their children, with sensory and motor behaviors at trend level $t(190) = -1.827$, $p = .069$ and rigid,

TABLE 2
Correlation Matrix for All Continuous Variables

	1	2	3	4	5	6	7	8
1. Sensory and motor behavior								
2. Rigidity, routines, restricted interests	.41***							
3. Socioeconomic status	−.23**	.02						
4. Maternal depression	.24**	.29***	−.24**					
5. Perceived social support	−.22**	−.19*	.33***	−.63***				
6. Appropriate mind-related comments	−.12	.02	.16*	−.08	.12			
7. Non-attuned mind-related comments	−.07	.03	−.05	.09	−.07	.07		
8. Maternal sensitivity	−.19*	−.02	.30***	−.28***	.28***	.39***	.04	
9. Child language	.18*	.04	.29***	−.16*	.27***	.27***	−.16*	.24**

Note. *$p < .05$, **$p < .01$, ***$p < .001$.

routinized, and ritualistic RRB significantly higher, $t(190) = -3.916$, $p < .001$. This supports the hypothesis that RRBs are related to maternal depressive symptoms.

Table 3 shows the RBQ-2 scores as a function of infant–mother attachment security. One-way ANOVA showed that four-way attachment security (secure, avoidant, resistant, disorganized) was not associated with sensory and motor behavior scores, F $(3, 186) = 0.36$, $p = .779$, or with rigidity, routines, and restricted interests scores $F(3, 186) = 0.53$, $p = .663$. When the attachment categories were collapsed to secure vs. insecure (avoidant, resistant, disorganized) attachment, there was no association with sensory and motor behavior scores, $t(188) = 0.07$, $p = .943$, or rigidity, routines, and restricted interests scores, $t(188) = 1.23$, $p = .222$ (see Table 3).

Independent predictors of RRB

The analyses reported above informed the regression analyses to identify independent predictors of the two subtypes of RRB. There was a trend for boys to reportedly engage in higher levels of sensory and motor behaviors compared with girls. Bivariate correlations showed that sensory and motor behaviors were correlated in hypothesized ways with SES, maternal depressive symptoms, perceived social support, maternal sensitivity, concurrent child language, and (at trend level) appropriate mind-related comments. The regression analysis first investigated whether gender, SES, maternal depressive symptoms, and perceived social support predicted independent variance in sensory and motor behavior scores. These variables were therefore added at step 1 of the regression analysis. As summarized in Table 4, at the first step, SES and maternal depressive symptoms predicted independent variance in sensory and motor behavior scores, with lower SES and higher depressive symptoms being associated with higher levels of sensory and motor behaviors.

If maternal interaction or child language mediates the relation between SES or depressive symptoms and sensory and motor behaviors, the significant effects of these predictors observed at the first step of the regression should become non-significant when the maternal interaction and child language variables are added to the regression equation. As summarized in Table 4, at the second step, maternal depressive symptoms remained a significant predictor of sensory and motor behaviors, with the predictive effect of SES being reduced to a strong trend. The results of the regression analysis thus suggest that relations between maternal depressive symptoms and SES and

TABLE 3
Restricted and Repetitive Behaviors as a Function of Infant–Mother Attachment Security

Attachment type	Sensory and motor M (SD), Range	RRR M (SD), Range
Avoidant	1.61 (.44), 1–2.56	1.61 (.41), 1–2.5
Resistant	1.47 (.37), 1–2.11	1.57 (.46), 1–2.38
Disorganized	1.65 (.33), 1.22–2.33	1.61 (.41), 1–2.5
All insecure	1.59 (.40), 1–2.56	1.60 (.41), 1–2.5
Secure	1.59 (.47), 1–3	1.53 (.41), 1–2.88

Note. RRR = rigidity, routines, restricted interests.

TABLE 4
Summary of Hierarchical Regression Analysis for Variables Predicting Sensory and Motor Repetitive
Behavior

Variable	B	SE B	β	p level
Step 1				
Child gender (0 = male, 1 = female)	−.09	.07	−.10	.179
Socioeconomic status	−.01	.003	−.17	.034
Maternal depression	.01	.003	.21	.034
Perceived social support	−.002	.01	−.03	.730
$R^2 = .11$, $F(4, 165) = 5.13$, $p = .001$				
Step 2				
Child gender (0 = male, 1 = female)	−.07	.07	−.08	.301
Socioeconomic status	−.01	.003	−.15	.066
Maternal depression	.01	.003	.20	.038
Perceived social support	−.001	.01	−.02	.878
Appropriate mind-related comments	−.00	.01	−.001	.993
Maternal sensitivity	−.003	.03	−.01	.923
Child language	−.002	.002	−.08	.340
$\Delta R^2 = .01$, $F(7, 162) = 3.04$, $p = .005$				

sensory and motor behaviors are not mediated by the quality of mother–infant interaction or children's language abilities.

Turning to rigidity, routines, and restricted interests, the analyses showed that this subtype of RRB was correlated only with maternal depressive symptoms and perceived social support. To establish whether these two maternal variables predicted independent variance in scores for rigidity, routines, and restricted interests, both were entered into a regression analysis. The regression was significant, $R^2 = .10$, $F(2, 168) = 9.09$, $p < .001$. Maternal depressive symptoms predicted independent variance in rigidity, routines, and restricted interests, $B = .01$, $SE\ B = .003$, $\beta = .33$, $p = .001$, but perceived social support was not an independent predictor of rigidity, routines, and restricted interests, $B = .001$, $SE\ B = .004$, $\beta = .02$, $p = .798$.

DISCUSSION

The results of the present study show that maternal depressive symptoms assessed in the first and second years of life predicted variance in both subtypes of RRB when children were age 26 months: higher levels of depressive symptoms were associated with higher reported levels of sensory and motor behaviors, and more rigidity, routines, and restricted interests. For sensory and motor behaviors, there was also a trend for lower SES to predict higher levels of this subtype of RRB. The observed findings for relations between maternal depressive symptoms and SES and children's sensory and motor behaviors were hypothesized. Previous research has shown an association between lower levels of environmental stimulation and engagement in sensory and motor repetitive behaviors in animals (Lewis et al., 2007), adults (Teng et al., 2002) and infants within the home environment (Berkson & Tupa, 2000), and depression is known to dampen mothers' responses to their infants and heighten negative and disengaged interactional behavior (Cox, Puckering, Pound, & Mills, 1987; Lovejoy et al.,

2000). Similarly, low SES is associated with lower levels of cognitive stimulation for the infant (Bradley & Corwyn, 2002; Evans, 2004), which may result in the infant engaging in sensory and motor repetitive behaviors as a form of self-stimulation. Elevated levels of sensory and motor repetitive behavior at age 2 are associated with poorer cognitive performance both concurrently and 2 years later (Larkin et al., 2017), so the observed finding that this subtype of RRB is predicted by maternal depressive symptoms and low SES is in line with previous research showing markers of atypical child development where mothers are depressed (Barker et al., 2012; Carter et al., 2001; Goodman et al., 1993; Murray & Cooper, 1997) or who come from low SES families (Bradley & Corwyn, 2002; Shaw & Vondra, 1995). Moreover, it is possible that sensory and motor behavior may inhibit positive parent–child interaction and contribute to maternal depressive symptoms, in line with research that higher stereotyped behavior in children with developmental disorders is associated with poorer maternal well-being (Griffith, Hastings, Nash, & Hill, 2010).

However, the positive association between maternal depressive symptoms and rigidity, routines, and restricted interests was not hypothesized. While sensory and motor repetitive behavior can be seen to be no longer adaptive beyond the first two years of life, rigidity, routines, and restricted interests begin to increase from age 2 and appear to be an adaptive aspect of typical development during the preschool years (Cevikaslan et al., 2014; Evans et al., 1997). We therefore did not expect a positive association between maternal depressive symptoms and this subtype of RRB. Moreover, rigidity, routines, and restricted interests were not related to SES, suggesting that this type of RRB is not a response to environmental privation or lower levels of cognitive stimulation.

One possibility is that the association between maternal depressive symptoms and rigidity, routines, and restricted interests may be explained in terms of infant stress. Infants of depressed mothers have been shown to exhibit difficulties with stress regulation from very early in development (Landy, 2000; Manian & Bornstein, 2009); as such, heightened levels of this kind of RRB at age 2 may demonstrate an attempt by the infant to regulate stress levels. Infants may be stressed by maternal depression through witnessing maternal sadness or experiencing maternal irritability or negativity (Landy, 2000; Murray & Cooper, 1997). This possibility is consistent with the explanation that normative rigidity, routines, and restricted interests (e.g., reading the same bedtime story) serve to reduce fear and uncertainty (e.g., Evans et al., 1997). By this account, an increase in stress may cause a corresponding increase in rigidity, routines, and restricted interests as a coping mechanism. However, Lovejoy et al. (2000) pointed out that the way in which a child responds to stress within their environment may depend on their own individual characteristics. It is possible that factors not measured in this study, such as executive function or emotion regulation, may underlie the infant's exhibition of rigidity, routines, and restricted interests (Bauer, Quas, & Boyce, 2002; Davidovich et al., 2016; Kagan, Reznick, & Snidman, 1988). Moreover, biochemical differences caused by in utero exposure to maternal depression may influence children's responses to stress (Pearson et al., 2013; Suri, Lin, Cohen, & Altshuler, 2014). Future research should explore these possibilities.

A second, though potentially related, explanation is the possibility of mothers and children sharing a genetic susceptibility to the spectrum of sensory sensitivity, affective disorders and neurodevelopmental disorders (Uljarević, Carrington, & Leekam, 2016; Uljarević, Evans, Alvares, & Whitehouse, 2016; Uljarević, Prior, & Leekam, 2014), or

the broader autism phenotype (Ingersoll, Meyer, & Becker, 2011). Recent family-based studies with children who have de novo 16p11.2 deletions (Moreno-De-Luca et al., 2015) and with probands with Down syndrome (Evans & Uljarević, 2018) show that parent–proband correlations in cognitive and/or social variables can be significant, which indicates that family background can make a sizeable contribution toward broader phenotypic variability. Similarly, family members of probands with attention deficit hyperactivity disorder are found to share many subclinical traits (Thapar, Cooper, Eyre, & Langley, 2013). More specifically, elements of RRB (intense preoccupations) have been found to be shared among probands with autism and their undiagnosed siblings and parents (Smith et al., 2009). Recent research suggests that RRB serves to regulate anxiety in ASD (Rodgers, Glod, Connolly, & McConachie, 2012; Wigham, Rodgers, South, McConachie, & Freeston, 2015); anxiety which is thought to arise from a combination of sensory sensitivity (Lidstone et al., 2014), intolerance of uncertainty, and difficulty accessing or understanding emotional states (South & Rodgers, 2017). As such, the underlying risks for RRB in children, and depression in mothers, may be shared. While only one of the children in the current sample was later diagnosed with an ASD, autistic traits, including restricted interests, are understood to be distributed within the normal population (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). Thus, elevated rigidity, routines, and restricted interests in the present study may indicate higher levels of anxiety or sensory sensitivity, or other broadly conceived autistic symptomatology, in the infants as a result of a shared genetic disposition with mothers.

Understanding the predisposing factors raises questions about the function of RRB. Are rigidity, routines, and restricted interests an attempt to self-regulate, while sensory and motor behaviors represent self-stimulation? The functions do not appear to be so easily divisible: It is possible that the same behaviors may serve different functions for children depending on their individual characteristics or on the demands of a situation. Joosten et al. (2009) found that the same motor and sensory behaviors (e.g., head banging) tended to be self-stimulatory in children with intellectual disabilities, but were used to escape situations by children with ASD. In addition, environmental conditions can influence the expression of RRB. For example, typically developing adults and children have been found to engage in sensory-based repetitive behavior (e.g., nail biting, hair twirling, thumb sucking) in situations provoking anxiety or low mood (Bohne, Wilhelm, Keuthen, Baer, & Jenike, 2002; Foster, 1998; Woods, Miltenberger, & Flach, 1996) and in mundane or unstimulating environments (Teng, Woods, Marcks, & Twohig, 2004; Woods et al., 2001). It is thus possible that the functions of both motor and sensory behaviors and rigidity, routines, and restricted interests will vary depending on child, situational, and parent factors (Leekam et al., 2011).

Turning to the associations between maternal and environmental factors and children's RRB, the present study's results ran contrary to our expectation that these factors would relate to RRB via mother–infant interaction. Rather, our findings in relation to sensory and motor repetitive behavior were more consistent with the thesis that maternal depressive symptoms relate to child RRB in conjunction with "third factor" variables such as low SES (Barker et al., 2012). Before accepting the view that mother–infant interaction does not mediate the relation between maternal depressive symptoms or SES and children's RRB, it is important to consider other aspects of interactional behavior. One possibility is that a brief measure of mother–infant interaction in the laboratory does not accurately reflect the responsiveness of the mother in day-to-day interactions. However, a meta-analysis by Lovejoy et al. (2000) on

observational studies of depression and parenting behavior reported that associations between depression and positive maternal behavior were strongest during unstructured, laboratory-based sessions. It may be that mother–infant interaction in depression differs along lines other than maternal sensitivity and mind-mindedness, and future research should investigate whether maternal expression of negative affect may help explain the relation between maternal depressive symptoms and children's RRB.

What implications might the findings of this study have for identifying and preventing maladaptive or abnormal RRB? The findings support the hypothesis that maternal depressive symptoms and RRB are related, and points toward shared genetic risk rather than parent–child interaction, although the mechanisms are not clear. Nevertheless, within a clinical or educational context, the presence of maternal depressive symptoms may be a useful factor to help identify children who are at increased risk of developing abnormal levels of RRB, and to offer preventative strategies, for example, improving children's general play skills or systematically targeting repetitive behaviors through parent-mediated intervention (see Harrop, 2015; Grahame et al., 2015).

Finally, it is important to acknowledge the limitations of the present study. First, we relied on maternal report of both depressive symptoms and children's RRB, which may have inflated the relation between these variables, especially when depressive symptoms were high. While parental report is generally considered appropriate for the assessment of RRB given the broad range of contexts in which parents observe the child (Harrop et al., 2014), it would be interesting to explore the relation between depressive symptoms and RRB using researcher and clinician ratings in addition to parental report. In addition, it would be useful to know whether the onset of depressive symptoms was antenatal or postnatal, to better understand the pathway of influence on the child (see Suri et al., 2014).

Second, the present study reported on predictors of children's RRB using a community sample rather than a clinical sample. Given our findings on the role of maternal depressive symptoms in predicting children's RRB, future research should explore whether clinical levels of depression in mothers are similarly associated with higher RRB in their children. In addition, our study focused on a relatively narrow definition of maternal mental health, assessing only depressive symptoms and perceived social support. Recent research from a prospective cohort study found that maternal depression only affected child development in combination with maternal anxiety (Ibanez et al., 2015), and recent research in the field of ASD indicates that RRB and sensory sensitivity are implicated in anxiety (South & Rodgers, 2017) and that in mothers as well as their children, sensory sensitivity is related to anxiety (Uljarević, Carrington, & Leekam (2016)). It would thus be essential to investigate whether other aspects of maternal mental health predict children's RRB.

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