STAGE 1 REGISTERED REPORT

Infant Learning from Fathers in a Social Referencing Paradigm: A Registered Report

Short title: Infant Learning of Anxiety from Fathers

Francesca Zecchinato, Jana Kreppner, Evin Aktar, Peter J. Lawrence

Francesca Zecchinato (*Corresponding author*)
Centre for Innovation in Mental Health,
School of Psychology,
Faculty of Environmental and Life Sciences,
University of Southampton, Southampton,
SO17 1BJ, UK
F.Zecchinato@soton.ac.uk

Jana Kreppner
Centre for Innovation in Mental Health,
School of Psychology,
Faculty of Environmental and Life Sciences,
University of Southampton, Southampton, UK
J.Kreppner@soton.ac.uk

Evin Aktar
Department of Clinical Psychology, Leiden University
Leiden Institute for Brain and Cognition (LIBC)
E.Aktar@fsw.leidenuniv.nl

Peter J. Lawrence
Centre for Innovation in Mental Health,
School of Psychology,
Faculty of Environmental and Life Sciences,
University of Southampton, Southampton, UK
P.J.Lawrence@soton.ac.uk

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Data Availability Statement

The data that support the findings of this study will be available from the corresponding author upon reasonable request. The authors will register the approved protocol on the Open Science Framework (https://osf.io/) either publicly or under private embargo until submission of the Stage 2 manuscript.

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Abstract

Anxiety disorders are among the most prevalent mental disorders among children worldwide. The exposure to parents' anxious behaviours represents an environmental risk factor for offspring anxiety and infant behavioural inhibition is prospectively associated with the broad class of anxiety disorders. However, fathers have been largely neglected in the study of child anxiety and their causal role in its intergenerational transmission remains to be investigated. In this experiment, we will test the impact of experimentally-manipulating fathers' socially anxious behaviours on their infants' behavioural and emotional responses to a stranger in a social referencing paradigm. Moreover, we will investigate the moderating role of infant behavioural inhibition. Twelve to 14-month-old infants (N sample size = XX; M age = XX; SD = XX) recruited in the county of Hampshire, United Kingdom, will participate in the study with their non-anxious fathers, who will be trained to interact in a neutral or anxious manner with two different male strangers. All infants will experience two conditions: (i) father interacting in a neutral (i.e., non-anxious) manner with the stranger, and (ii) father interacting in a socially anxious manner with a different stranger. The order of each condition and the order of stranger presentation will be counterbalanced. This experimental study will help shed light on the causal role of fathers' anxious behaviours in the intergenerational transmission of anxiety.

Keywords

anxiety, fathers, social referencing paradigm, infants, behavioural inhibition

Public Significance Statement

- Anxiety disorders are common in children, and parental anxiety as well as infant behavioural inhibition represent risk factors for their development.
- Results from this experimental study showed that infants can learn/do not learn from observing fathers' anxious behaviours in a social referencing paradigm, and that infant behavioural inhibition moderates/does not moderate the association between paternal and infant behaviour, such that the predictive relation between paternal anxious behaviour and infant fearfulness/avoidance is increased/not increased by infant behavioural inhibition.
- By shedding light on the role played by fathers' anxious behaviours, this work adds to the evidence on the processes involved in the intergenerational transmission of anxiety and, ultimately, can contribute to the prevention of child anxiety disorders.

INTRODUCTION

Anxiety Disorders (ADs) are the most common group of mental health disorders in children, with a worldwide prevalence of approximately 6.5% (Polanczyk, Salum, Sugaya, Caye, & Rohde, 2015), and represent the sixth leading cause of disability globally (Baxter, Vos, Scott, Ferrari, & Whiteford, 2014). As demonstrated by a recent meta-analysis, the earliest peak onset for anxiety and fear-related disorders is at five and a half years, while the median age at onset is 17 years (Solmi et al., 2022). Indeed, it is estimated that ADs have already emerged before age 14 in more than 38% of individuals (Solmi et al., 2022). Further, ADs have long-lasting negative impacts on daily functioning and multiple life domains, including educational under-attainment, peer victimization, and later physical and mental health disorders (Cabral & Patel, 2020; Lawrence, 2018). For these reasons, ADs represent a serious burden for both individuals and societies and are considered a major health priority (Yang et al., 2021). Hence, their prevention is desirable and the detection of modifiable risk factors is crucial for the identification of possible targets in prevention, that can then inform effective prevention strategies.

ADs aggregate in families. Indeed, ADs in parents, compared to their absence, are associated with a significantly increased prevalence of offspring ADs (Lawrence, Murayama, & Creswell, 2019; Micco et al., 2009), making parental AD an important risk factor for child ADs. However, the mechanisms underlying these familiar associations remain unclear. Theoretical frameworks of anxiety development in children highlight two main pathways of parent-to-child anxiety transmission (Fisak & Grills-Taquechel, 2007; Murray, Creswell, & Cooper, 2009), namely the inheritance of genetic risk factors and the exposure to environmental stressors. The heritability of ADs is estimated in the range of 20 to 60% (Craske et al., 2017; Polderman et al., 2015); however, candidate gene studies of ADs have not found robust gene-disorder associations (Smoller, 2016) and research suggests that a

multitude of common genetic variants with modest effects and shared with other internalising disorders accounts for the risk for ADs (Purves et al., 2020; Smoller, 2016). Further, studies genetically informed to examine the intergenerational transmission of risk (Ahmadzadeh et al., 2019; Eley et al., 2015) have demonstrated that the association between parental and offspring anxiety is not significantly confounded by genetic relatedness. Hence, it is likely that a combination of genetic vulnerability and environmental stressors contribute to the aetiology of ADs in offspring (Purves et al., 2020; Smoller, 2016), with a significant body of evidence supporting the key role of environmental influences in the intergenerational transmission of anxiety (Eley et al., 2015; Murray et al., 2009).

Particular parenting practices that increase children's sense of threat or limit their opportunities to tackle challenges, and thus develop a sense of mastery over the environment, are proposed to contribute to the development of child ADs and have been found to be particularly common in parents with ADs (Murray et al., 2009). Evidence from meta-analyses indicates that parental behaviours, at a broad level, play a small and significant role in the development of child anxiety (McLeod, Wood, & Weisz, 2007; Möller, Nikolic, Majdandzic, & Bögels, 2016). Furthermore, these meta-analyses make the case for the importance of conceptual specificity, which can be obtained by disaggregating parenting dimensions into more specific components (McLeod et al., 2007) and by distinguishing between particular types of parenting behaviours, for example overcontrol and overprotection (Möller et al., 2016). Indeed, examining specific parenting practices, such as expressed anxious behaviours rather than overcontrol, in specific contexts, such as with or without a social stressor, can clarify their contribution (e.g., Lawrence, Creswell, Cooper, & Murray, 2020; Murray et al., 2012), which may be lost when parenting practices are examined at a broader conceptual level (McLeod et al., 2007; Möller et al., 2016).

Specifically, theoretical accounts suggest that parents may environmentally transmit anxiety to their children via a social learning pathway (Bandura & Walters, 1977; Olsson & Phelps, 2007), that is by the modelling of anxious behaviours or by the verbal communication of threat-relevant information, in social situations (Askew & Field, 2008; Bandura & Walters, 1977; Fisak & Grills-Taquechel, 2007; Murray et al., 2009). Observational and experimental studies support the importance of modelling in the intergenerational transmission of parental anxiety to toddlers and infants. For example, in their longitudinal study, Murray et al. (2008) found that, compared to a control group of mothers without ADs, mothers with Social Anxiety Disorder (SAD) expressed more anxiety (via facial, bodily and verbal cues, such as worried or fearful expressions, tense posture, wringing hands, and rushed or agitated speech) in a social referencing (SR) paradigm, where they engaged in a conversation with a female stranger while their 10-month-old infant observed the interaction and the infant's response to the stranger was assessed. More importantly, the expressed signs of anxiety in mothers with SAD predicted increased infant social avoidant behaviours four months later, in particular during the more stressful moments of the interaction between the infant and the stranger (i.e., when the stranger picked the infant up; Murray et al., 2008). With a similar SR task, Aktar, Majdandžić, De Vente, and Bögels (2013) reported that, at 12-months, parents' expressed anxiety, but not parental lifetime anxiety disorders, predicted infant avoidance during interactions with social (i.e., a stranger) and non-social (i.e., a mechanical dinosaur) novel stimuli, complementing previous studies and indicating that, at 12 months, parental expressions of anxiety in the moment via bodily, facial and verbal cues have a greater impact than their lifetime anxiety diagnoses in the social learning of fear. Adopting an experimental design, Gerull and Rapee (2002) showed that, compared to positive facial expressions, the manifestation of disgust and fear by non-anxious mothers in the presence of a novel object resulted in stronger avoidance behaviour or fearfulness on behalf of their toddlers, providing

evidence of a potential causal influence of expressed anxious parenting behaviours on offspring anxious reactions.

Another crucial gap in our knowledge concerns the specific impact of fathers in the intergenerational transmission of psychopathology, especially in light of the evidence that fathers and mothers are likely to influence their children's symptomatology in different ways (Bögels & Phares, 2008; Natsuaki et al., 2014; Ramchandani & Psychogiou, 2009). With specific regard to ADs, evolutionary theories of parenting assign fathers an important role in the development of social anxiety due to their pre-agrarian role in dealing with the social world beyond the extended family or clan, and in encouraging their children's autonomy (Bögels & Phares, 2008; Bögels & Perotti, 2011). Arguably, cultural factors are likely to influence the way parents behave across cultures, societies and historical eras (Chen et al., 1998; Paquette, 2004), thus making parental roles subject to differences and transformations, and potentially limiting the utility of evolutionary frameworks. Notably, Aktar et al. (2013) found no significant difference between mothers and fathers in the strength of the associations between expressed parental anxiety and infant avoidance, pointing to an equally important role of fathers and mothers in the intergenerational transmission of anxiety in infancy (Aktar et al., 2013). This is a particularly relevant finding considering that, historically, fathers have been largely neglected in the study of child anxiety and, more generally, in the field of developmental psychopathology (Bögels & Phares, 2008). This tendency may have been motivated by practical assumptions, such as that mothers are easier to involve or more willing to take part in research compared to fathers (e.g., Phares & Compas, 1992), as well as more general assumptions, including that mothers spend the majority of time with their infants and thus have a greater impact on their development, and that, overall, mothers matter more than fathers (Bögels & Phares, 2008; Lamb, 2000). However, these assumptions lack empirical support. Indeed, research shows that the

engagement in studies is more related to factors such as the amount of involvement required rather than parent gender (Phares & Compas, 1992), and that quality, rather than quantity, of parental involvement has greater influence on child development and wellbeing (Amato & Rezac, 1994; McBride, Schoppe, & Rane, 2002). Moreover, although their roles change over time and may vary significantly between different societies and cultures, fathers have an active presence in childcare in most countries and cultures, and seem to have a stronger influence on their children's development than what was assumed in the past (Ramchandani & Psychogiou, 2009); hence, a thorough examination of fathers' influences in the context of ADs transmission is warranted.

Child temperamental dispositions are also important in relation to the developmental of ADs. Behavioural inhibition (BI), which is often referred to as negative reactivity to novelty, social reticence or fearful temperament in early infancy (Fox, Henderson, Rubin, Calkins, & Schmidt, 2001; Kagan & Snidman, 1991), refers to the biologically driven temperamental characteristics of fear, avoidance, and withdrawal in novel situations or with unfamiliar people and / or objects (Kagan, Reznick, & Snidman, 1987). BI in infancy and early childhood is prospectively associated with the broad class of ADs (Degnan & Fox, 2007), almost tripling the odds of developing subsequent anxiety disorders (Sandstrom, Uher, & Pavlova, 2020). BI represents a particularly strong risk for later SAD (Clauss & Blackford, 2012; Sandstrom et al., 2020) and has been shown to account for approximately 10.4% of the total variance in its development in the second year of life (Paulus, Backes, Sander, Weber, & von Gontard, 2015). This might be explained by a combination of genetic factors, similarities in core features of BI and SAD, as well as the measures used to assess BI (Sandstrom et al., 2020).

The exposure to parental expressed anxiety may interact with infant BI, making high BI infants particularly susceptible to that environmental stressor. This hypothesis is in line

with the diathesis-stress (Zuckerman & Riskind, 2000) and vulnerability-stress (Ingram & Luxton, 2005; Nigg, 2006) models, according to which genetic vulnerability and environmental factors, independently and in combination, increase the liability to a disorder. Evidence from the literature on the intergenerational transmission of anxiety in infancy using SR paradigms supports the interplay between parental anxiety and BI on child fearful and avoidant reactions. In studies from the UK in mothers with ADs (Murray et al., 2008), and the Netherlands in parents (both mothers and fathers; Aktar et al., 2013), SR paradigms were adopted to examine differences between infants of anxious parents and non-anxious parents. Murray et al. (2008) found that, following a SR task at 10 months, the association between maternal SAD and infant avoidance of an adult stranger was moderated by infant BI. Specifically, for behaviourally inhibited infants, compared to non-behaviourally inhibited infants, the increase in avoidance was greater and extended to the less stressful episodes of the infant-stranger interaction (e.g., during the graded approach of the stranger). Aktar et al. (2013), using a very similar SR task with 10-month infants, reported a positive association between expressed parental anxiety and infant avoidance *only* among infants with moderate-to-high BI.

Crucially, the end of the first year of life is a particularly sensitive period for the exposure to environmental adversity (Goodman & Gotlib, 1999; Leppänen, 2011) and for the social learning of anxiety because of the emergence of SR skills. SR is the process infants typically begin to use between 7 and 10-months of age of seeking information about unfamiliar objects, people or situations from a social interaction partner (such as a parent), in order to inform their own emotions and behaviours towards that unfamiliar object, person or situation (Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998; Feinman, 1982; Feinman, Roberts, Hsieh, Sawyer, & Swanson, 1992). It is argued that SR processes may be

especially relevant to the study of SAD, as the development of SR skills also coincides with the onset of the wariness of strangers (Sroufe, 1977).

Taking into account the state of the art, the need emerges to test experimentally the causal role of fathers' expressions of anxiety in infants' subsequent anxious behaviour and affect. It is important to acknowledge that studies employing longitudinal semi-experimental designs with clinically anxious parents do not allow for inferences to be drawn regarding causal relationships between parental expressions of anxiety and observed infant anxious responses. Indeed, infants of clinically anxious parents have a learning history of observing anxiety in their parents' day-to-day behaviours, thus it is not possible to disentangle the effect of infants' observations of parents' anxious behaviours in a laboratory setting from the influence of their parents' day-to-day anxious parenting (e.g., verbal information transfer, overcontrol, overprotection; see Möller et al., 2016; Murray et al., 2009). On the contrary, in their experimental study, de Rosnay, Cooper, Tsigaras, and Murray (2006) tested the causal effects of anxiety expressions towards male strangers in *non*-anxious mothers' behaviours, which were experimentally manipulated to be either socially anxious or neutral, on their 12-to-14 month-old infants responses to the same strangers. The results showed that when those infants, who had no anxious learning history, observed their mothers act anxiously with the stranger, they showed more anxious behaviours (i.e., were more fearful and avoidant) in their own interactions with the same stranger, compared to when the infants observed their mothers engaging in a neutral interaction with the stranger. Moreover, in line with the earlier literature, this effect was moderated by infant temperament. That is, the anxiogenic effect of parental anxious behaviours was greater for infants classified as high in BI than for those classified as low in BI (de Rosnay et al., 2006). This study provides a demonstration of a causal role for maternal anxious behaviours on infants' anxious responses in a SR paradigm, moderated by infant temperamental inhibition. However, it remains unknown whether infants

without a learning history of observing anxiety in their *fathers* respond anxiously after observing their (non-anxious) fathers react anxiously to an adult stranger in a SR paradigm.

Given the particularly early onset of ADs and the need to better understand the role of fathers in the parent-to-offspring anxiety transmission, building on the evidence highlighting the end of infancy as a sensitive period for the exposure to parental anxious behaviours, the present experimental study targets father-infant dyads with the aim to advance our knowledge of the social learning of anxiety from fathers and of the moderating influence of infant BI. Specifically, we will address the following research questions: 1) do fathers' behaviours (anxious vs neutral) while interacting with an adult stranger influence their infants' emotional and / or behavioural responses (as happens with mothers), and 2) is the association between paternal anxious behaviours and infant anxious responses moderated by infant BI?

Building on the social learning accounts for the development of ADs in infancy (Bandura & Walters, 1977; Murray et al., 2009; Olsson & Phelps, 2007) and on the interplay between temperamental susceptibility and environmental stressors supported by the diathesis-stress (Zuckerman & Riskind, 2000) and vulnerability-stress (Ingram & Luxton, 2005; Nigg, 2006) models, and in line with previous SR literature examining the intergenerational transmission of anxiety (e.g., Aktar et al., 2013; de Rosnay et al., 2006; Murray et al., 2008), we hypothesise that:

1) Infants' reactions to a stranger will differ between two conditions of observation of their fathers' behaviour towards the stranger. Specifically, we predict that infants will display more fearful and avoidant behaviours towards a stranger whom they have observed their father interact with in a socially anxious manner (i.e., anxious condition), compared to when they have observed their father interact with a stranger in a neutral (non-anxious) manner (i.e., neutral condition);

2) the association between paternal behaviour and infant fear and avoidant behaviours will be moderated by infant BI. Specifically, infants high in BI will display significantly more anxious behaviours in the anxious condition compared to infants non-high in BI.

MATERIALS AND METHOD

2.1 Design

To draw a firm conclusion about the impact of non-anxious fathers' socially anxious behaviours on their infants' behavioural and emotional responses (i.e., fearfulness and avoidance), we will conduct a within-subjects laboratory-based experiment with father-infant dyads using a SR paradigm, assessing the role of paternal behaviours (neutral vs anxious) and infant BI (high vs non-high) in infant responses while interacting with a male stranger. All infants will experience two conditions: father interacting in a neutral (i.e., non-anxious) manner with a male stranger, and father interacting in a socially anxious manner with a different male stranger. To minimise the impact of order effect, we will counterbalance the order of each condition, as well as the order of stranger presentation, hence resulting in four combinations. Equal numbers of boys and girls will experience each combination.

2.2 Participants

Opportunity sampling will be used to recruit father-infant dyads for our study. de Rosnay et al. (2006) reported a medium effect size of $d = .58$ for the main effect of condition (anxious vs neutral) on infant fearful behaviours. For interactions, they reported a large effect of $d = 1.35$ for anxious condition with BI (high vs low), and a very large effect of $d = 2.48$ for the interaction of condition (neutral vs anxious) with high BI on infant avoidance behaviours. Limited by the absence of comparable studies available, we took a more conservative approach and based our analyses on smaller effect sizes, as recommended in such circumstances (Ellis, 2010). We used G*Power software (Faul, Erdfelder, Lang, & Buchner,

2007) to calculate an a priori sample size, with *alpha* set to .05. The analyses showed that 70 father-infant dyads would be sufficient to detect a small to medium effect size (Cohen's f = 0.2) in our primary hypothesis (i.e., effect of anxious vs neutral condition on infant reactions) at 90% power. This sample size also gives us 80% power to detect a small to medium effect size (Cohen's f = 0.17) in our Hypothesis 2 (i.e., interaction between condition and infant BI). To be eligible for inclusion in the SR task, fathers will be required to be 18 years old or above, fluent in English, with no learning disability, no current anxiety diagnosis and no clinically relevant anxiety symptoms in the past 12 - 14 months (i.e., since the baby was born). We will assess that participants score below clinical cut-offs for anxiety via screening questionnaires completed prior to the SR task itself. Moreover, they will be fathers of a typically developing infant (i.e., birth weight over 2500g without any congenital health difficulties) aged between 12 and 14 months. Participants will be recruited in the Southampton area, United Kingdom, through advertisements across the University of Southampton, local parent-baby groups, local nurseries, and via social media (e.g., Twitter). Overall, XXX fathers completed the online screening questionnaires (Mage = , SD =). XXX were excluded because XXX. Our final sample comprised XX boys and XX girls, between 12 and 14 months of age (Mage = ; SD =), and their fathers (Mage = ; SD =) (see **Table 1** for demographics details). All participants will provide informed consent prior to every session (i.e., online and in-person) of the study. Ethical approval has been granted from the University of Southampton Research Governance and Ethics Committee (reference number: 53935).

2.3 Material

2.3.1 Screening Measures

Fathers interested in taking part in the study will complete a range of demographic questions (i.e., age, ethnicity, education, employment status, household income, religion,

sexual orientation, marital status, partner's anxiety, and household type) and questionnaires via Qualtrics to assess their eligibility to participate. Specifically, the 16-item Penn State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger, & Borkovec, 1990), the 20-item Social Interaction Anxiety Scale (SIAS; Mattick & Clarke, 1998), and the 7-item Generalized Anxiety Disorders Scale (GAD-7; Spitzer, Kroenke, Williams, & Löwe, 2006) will be used to screen for anxiety symptoms. The cut-offs to identify anxiety symptoms (hence leading to exclusion from the study) will be a score ≥64 for the PSWQ (Meyer et al., 1990), ≥36 for the SIAS (Peters, 2000), and ≥8 for the GAD-7 (Kroenke, Spitzer, Williams, Monahan, & Löwe, 2007). Hence, only fathers who score lower than these cut-offs on *all* these measures will be eligible to participate. The internal reliability of these measures was poor/adequate/excellent in our study (PSWQ *Cronbach's a* = XX; SIAS *Cronbach's a* = XX; GAD-7 *Cronbach's a* = XX).

Depressed parents, compared to non-depressed parents, tend to display more flat affect and more negative facial expressions (e.g., Field, 1992; Striano, Brennan, & Vanman, 2002); further, parental depression may exert an impact on infant behavioural and emotional responses (e.g., Sweeney & MacBeth, 2016); hence, we will assess depressive symptoms and adjust for their effect using them as a covariate. Fathers will complete the 10-item Edinburgh Postnatal Depression Scale (EPDS; Cox, Holden, & Sagovsky, 1987). Given the sensitive nature of its question about the thought of self-harm, the EPDS will be administered to fathers when visiting the University, with members of the research team on hand to assess and manage risk, prior to completing the SR tasks with their infant. Participants will not be excluded on the basis of the EPDS scores; however, any participants who will endorse the risk item on the EPDS (i.e., they indicate that they have recently experienced thoughts of harming themselves) will be offered support to contact their general practitioner (GP / family

doctor). In the current study, the internal reliability of this questionnaire was poor/adequate/excellent (*Cronbach's a* = XX).

2.3.2 Infant BI

At the screening phase, fathers will complete the fear subscale of the Infant Behavior Questionnaire – Revised (IBQ-R; Gartstein & Rothbart, 2003), which will be used to measure infant BI. The IBQ-R is a 191-item parent-report measure that assesses 14 domains of infant temperament, namely approach, vocal reactivity, high intensity pleasure, smiling and laughter, activity level, perceptual sensitivity, sadness, distress to limitations, fear, falling reactivity, low intensity pleasure, cuddliness, duration of orienting, and soothability using a 7-point Likert scale (1 – *never* to 7 – *always*, with a *does not apply* option if the event did not occur within the time span of interest). For the purpose of our study, and building on de Rosnay et al. (2006), we will only focus on the fear domain, which refers to a child's startle to sudden changes in stimulation, inhibited approach to novelty and distress in the presence of novel physical objects or social stimuli (Gartstein & Rothbart, 2003) and has a theoretical overlap with the construct of BI (Gagne, Vendlinski, & Goldsmith, 2009). Previous research found moderate significant convergence between parent-reported and laboratory-observed infant temperamental fear, as well as between father and mother reports (e.g., Braungart-Rieker, Hill-Soderlund, & Karrass, 2010; Gagne, Van Hulle, Aksan, Essex, & Goldsmith, 2011; Gartstein & Marmion, 2008; Gartstein & Rothbart, 2003; Planalp, Van Hulle, Gagne, & Goldsmith, 2017; Rothbart, 1981).

We will screen for BI to create a balanced sample of highly behaviourally inhibited and non-highly behaviourally inhibited infants. Specifically, based on the scores in the IBQ-R-fear obtained by 12 to 14 month-old infants worldwide (S. Putnam, personal communication, September 27, 2022), those who score on the 80th percentile or above (i.e., ≥ 3.5) in the IBQ-R-fear will be classified as high BI, those who score below the 80th percentile

(i.e., < 3.5) will fall within the non-high BI group. Scores in the IBQ-R-fear ranged from XX to XX (M = XX, SD = XX). The mean score for the non-high BI group was XX (SD = XX), and the mean score for the high BI group was XX (SD = XX). For our sample, the internal reliability for the IBQ-R-fear was poor/adequate/excellent (*Cronbach's a* = XX).

2.3.3 Paternal Training Material

Two short videos (for details see Videos S1 and S2 of the online supplement) were recorded of a man role-playing both a neutral (i.e., non-anxious) and a socially anxious interaction with a male stranger, in line with the DSM-5 clinical descriptions of SAD and observations of social anxiety in a SR paradigm (Murray et al., 2008). These included bodily behaviours, such as tense posture, wringing hands, and poor eye contact (i.e., frequent looks towards hands / floor during the social interaction, attention drifted around the room without a focal point), and facial expressions of anxiety, such as lip-biting, grimaces, facial twitches or rapid blinking, worried or sad expressions. Conversational dimensions included nervous laughter and limited responses to questions. Based on de Rosnay et al. (2006), the behaviours in the neutral video were relaxed posture, good eye contact (i.e., attention either directed mainly at the stranger or smoothly shifted between the stranger and the infant), and a friendly expression that suggests openness (e.g., appropriate back-channelling cues such as nodding and small agreement smiles). The quality of speech was characterised by complete answers to questions and a conversational tone that encouraged further dialogue.

In line with previous studies (de Rosnay et al., 2006; Murray et al., 2008), as a manipulation check to assess the effectiveness of paternal training, a research assistant, blind to the study hypotheses and to the condition displayed in the video, will rate paternal anxiety during the father-stranger interaction on a 5-point Likert scale (1 – *no anxiety* to 5 – *pervasive social anxiety*) using the coding protocol for the stranger SR task by Murray et al. (2008). To assess the inter-rater reliability and alleviate the threat of restricted range, a second coder will

rate 20% of the father-stranger interaction clips. Percentage agreement and interclass correlation coefficients (ICCs) were as follows: % and XX. Adopting the criteria proposed by Jacobson and Truax (1992) to test for a reliable change between conditions, and depending upon the means and standard deviations in our sample, for the neutral scenario, we will exclude any fathers whose expressed anxiety score is 2 SD above the mean calculated for the neutral condition; conversely, for the anxious scenario, we will exclude any fathers whose anxiety score is 2 SD below the mean calculated for the anxious condition. In the socially anxious condition, fathers' mean score was XX (SD = XX), while in the neutral condition the mean anxiety score was XX (SD = XX). A subsequent paired-samples *t*-test will reveal whether the difference is significant/non-significant.

2.3.4 Strangers

Strangers will be two adult males of similar height and appearance and matched for ethnicity. In line with the methods adopted by de Rosnay et al. (2006), before the SR tasks, the strangers will be adequately trained in the procedure. Strangers will be taught to approach the infant gradually and converse in a neutral, reliable and consistent manner across conditions. Additionally, they will memorise a scripted set of questions to ensure a smooth and reliable conversation with the fathers.

2.4 Procedure

To develop our experimental procedure and study design, we have consulted (via a virtual meeting) a group of fathers with relevant lived experience of anxiety, and we intend to maintain their involvement throughout the study process for dissemination purposes ("UK Standards for Public Involvement," 2019). Indeed, a growing body of evidence illustrates how Patient and Public Involvement (PPI) in mental health research can bring substantial benefits to research, improving the experience of participating in studies, making research

more relevant and beneficial to the wider public, and impactful (Brett et al., 2014; INVOLVE, 2016).

The study will comprise an online screening session followed by an in-person experimental session at the School of Psychology, University of Southampton, and will be advertised across the University of Southampton, local parent-baby groups and nurseries, and via social media (e.g., Twitter) as a research study about 'How babies learn in social situations'.

Participants who, in principle, are interested in taking part, will be asked to complete the demographic questions and screening questionnaires (i.e., the PSWQ, SIAS, and GAD-7), as well as the IBQ-R-fear on Qualtrics. If they meet the eligibility criteria, participants will be able to arrange their visit at the University with their infant.

The university visit will have three phases. First, completion of the EPDS, second, father training and, third, the SR task. In the training phase, fathers will be informed about the overall experimental procedure. On each of two occasions, fathers will interact with a different male stranger, who will enter the laboratory and engage in conversation with them; on one occasion, fathers will be asked to behave as they would in an everyday interaction with a stranger (neutral condition); on the other occasion, fathers will be asked to pretend that they feel nervous and slightly fearful about interacting with the stranger (socially anxious condition). The two short training videos, depicting a man in each condition, will be used for illustration. Each video will be shown twice. The first time, the video will be viewed without sound and the focus will be on the behaviours displayed. The second time, emphasis will be given to more qualitative aspects of conversation. In both cases, the researcher will pause the footage and highlight relevant features. Finally, fathers will be asked to rehearse the neutral and anxious responses along with the researcher. Fathers will be trained not to look at their

infant during the two experimental conditions, while they will be asked to interact with their infant in a normal manner between conditions.

In line with the procedure adopted by de Rosnay et al. (2006), in the SR task phase, the father and infant dyad will sit 3.0 m apart, each located approximately 3.5 m away from the doorway. The infant will be strapped into a highchair, next to an empty chair for the stranger (positioned to the infant's left). Next to the father's chair, there will be a selection of magazines to read. After a brief period of acclimatisation, where the father will have the opportunity to ensure his infant is settled, the SR phase will begin. This phase will include two subsequent episodes and will last 3 minutes in total. In the first episode (father-stranger interaction), the stranger, after knocking, will enter the laboratory room, staying near the doorway. The stranger will greet the father and start a conversation lasting approximately 90s concerning general activities and experiences of the infant and the family. During this time, the stranger will sit facing the father, without attending to the infant. In the second episode (infant-stranger interaction), lasting approximately 60s, the stranger will first inform the father about his intention to talk to the infant and ask the father to read a magazine, disregarding the infant. Next, the stranger will greet and gradually approach the infant. The stranger will increase his engagement with the infant calling the infant's name, offering them a small toy and, finally, extending his arms in a position to pick the infant up. The stranger will then leave the laboratory. See **Figure 1** for an overview of the study procedure.

Before the arrival of the second stranger for the second social interaction task, the father will have the opportunity to ensure his infant is settled. The second stranger will then enter the laboratory room and the two episodes will be repeated.

Fathers will be advised regarding which condition they should engage in first immediately before the SR task phase begins. Strangers will be blind to the condition at

entry. The experiment will be videorecorded using two wall-mounted cameras; one camera will record the overall picture, the other will provide a full-face image of the infant.

2.4.1 Infant Behaviour during the SR Tasks

In this study we aim to test whether infants model the observed paternal behaviours when they are confronted with a novel person in a social context. Hence, as a quality check, to ensure that the infant observes their father's behaviours in both experimental conditions, during the first minute of each father-stranger interaction, the number of times the infant looks in the direction of their father will be assessed. In the unlikely instance of no looks towards the father in one or both the experimental conditions, the dyad will be excluded from the study. During the infant-stranger interaction, we will assess two dimensions of infant affect, namely avoidance and fearfulness. Infant-stranger avoidance refers to infant attempts to avoid contact and interaction with the stranger, including behaviours such as turning their back on the stranger, increasing distance between self and the stranger, averting gaze or avoiding eye contact, and ignoring the stranger (Ainsworth, Blehar, Waters, & Wall, 1978). Infant-stranger fearfulness captures a range of behaviours defined as fearfulness and wariness (e.g., Schaffer, Greenwood, & Parry, 1972; Sroufe, 1977; Stevenson-Hinde & Shouldice, 1990) and includes fearful or wary expressions, sudden decrease in activity, tense or frozen postures, cry faces, fretting, fussing, whimpering, or crying.

2.4.2 Scoring

The first author, blind to the experimental conditions, will score all footage of infants interacting with strangers. Footage showing only the infant will be scored and, to avoid any cues about which experimental condition the infant was experiencing, the infant-stranger interaction of both conditions will always be scored before the father-stranger interaction. The number of times the infant looks at their father's face during the father-stranger interaction will be counted.

Infant affect dimensions will be assessed during the stranger's gradual approach and interaction with the infant. For the purposes of scoring, and in line with the coding protocol by Murray et al. (2008), this episode will be divided into five phases lasting approximately 10–12 seconds: (1) calls infant's name, approaches, and seats himself next to the infant; (2) talks to the infant; (3) shows the infant a toy; (4) reaches out and lightly touches infant's leg while continuing to talk with the infant; (5) stands up and stretches out his arms, as if to lift the infant. For each of the five phases, each infant affect dimension will be rated on a five-point scale (1 – *absent* to 5 - *very frequent*).

A second trained researcher, who will be blind to the study hypotheses, will score the footage from nine subjects, randomly chosen from the sample (i.e., 18 clips; ~25% of the sample). The ICC used to assess inter-rater reliability for infant looks to their father's face revealed poor/moderate/good/excellent agreement (XX). Percentage agreement and ICCs for infant affect were as follows: % and XX for avoidance and % and XX for fearfulness.

2.5 Analysis strategy

In line with de Rosnay et al. (2006), we hypothesise that infants will modify their reactions in accordance with the condition of observation of their fathers' behaviour towards the stranger (anxious vs neutral). Moreover, we expect the association between paternal behaviour in the two experimental conditions and infant responses to be moderated by infant BI. Specifically, infants high in BI, compared to infants non-high in BI, will display significantly more anxious behaviours in the anxious condition.

We will not exclude any participants based on their performance on the experimental tasks. However, we will exclude the dyad from the study if fathers are not rated as expressing anxiety in the anxious condition (i.e., score 2 SD below the mean for that condition) or are rated as expressing anxiety in the neutral condition (i.e., score 2 SD above the mean for that condition), and / or if infants do not look towards their father during the father-stranger

interaction. Electronical data from the screening phase will have been submitted before the experiment begins (i.e., participants will not have the option to skip questions). If a participant decides to withdraw from the laboratory session, when possible, the reasons for the withdrawal will be recorded for the subsequent interpretation of the results. In the laboratory phase, provided that the dyads fully complete the session, the only instance of missing data would be if the electronic devices (i.e., recording tools) fail. In this case, we will exclude the dyad from the study, unless at least 80% of each of the two SR tasks (approx. 72s) has been adequately recorded.

Before proceeding with the main analyses, as a quality check, we will use *t*-tests to assess whether infants' reactions (i.e., fearfulness and avoidance) to the two strangers are comparable or whether there are any significant differences. If a stranger effect emerges, we will account for it as a covariate in the analyses. Some studies suggest that girls may be more sensitive to expressions of parental affect, and react more strongly when their mothers express fear towards a referent (Blackford & Walden, 1998; Gerull & Rapee, 2002), thus we will evaluate whether infant sex plays a role in their responses. We will run a Chi-Square test to examine whether there is an association between infant sex and BI. If the association is significant, we will adjust for the effect of sex, which will be accounted for as a covariate in the analyses. For each infant behaviour, we will compare the neutral and socially anxious conditions, first examining whether order of condition presentation influenced infant responding, and then accounting for the possible influences of infant sex and BI. R Statistical Software version 4.1.2 (R Core Team, 2021) will be used to conduct data analyses for this study. Significance levels will be set at $\alpha = .05$ for all statistical tests except analyses of simple effects, where an α of .01 will be employed. We will adjust for multiple comparisons using the Holm-Bonferroni method.

2.5.1 Infant Looking

We will first calculate the mean number of infant looks in the direction of the father's face during the father-stranger interaction in both neutral and socially anxious conditions. To examine whether infant looking to father was influenced by order of condition presentation, we will run a mixed-model ANOVA using condition (neutral vs anxious) as the within-subjects factor and order as the between-subjects factor.

2.5.2 Infant Affect

We will calculate the mean affect scores (i.e., fearfulness and avoidance) during the infant-stranger interaction for both the neutral and socially anxious condition (see **Table 2** for the descriptive statistics for infant fearfulness). To determine the potential influence of order presentation, for each affect dimension we will conduct a mixed-model ANOVA using condition as a within-subjects factor and order as a between subjects factor. **Table 3** reports the effect of condition and order on infant fearfulness.

Fearfulness. To assess whether infant fearfulness was influenced by infant sex or BI, two separate mixed-model ANOVAs will be run, with condition as a within-subjects factor and sex and BI as between-subjects factors. All two-way interactions will be considered (see **Table 4** and **Table 5**).

Avoidance. Two mixed-model ANOVAs will be conducted with condition as a within-subjects factor, and sex and BI as between-subjects factors. All two-way interactions will be considered.

2.6 Timeline

Following Stage 1 submission and, eventually, in principle acceptance, we plan to start data collection. We anticipate the data collection, analysis and writing-up to take approximately 12 months. After this process, we will submit the finalised manuscript for re-review (Stage 2).

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TABLES AND FIGURES

Table 1 Sociodemographic characteristics of the included sample.

	Fathers (N =)	Male infants (N =)	Female Infants (N =)
Age M *(SD)*			
Ethnicity (%)			
White			
Back			
Asian			
Other ethnic group			
Household type (%)			
Two-parent household			
Single-parent			
household			
Education			
Employment status			
Income			

Table 2 Descriptive statistics for infant fearfulness.

Condition	Order	Mean	Std Deviation	N
Anxious	Anxious-Neutral	xx.xx	x.xx	xx
	Neutral-Anxious	xx.xx	x.xx	xx
Total		xx.xx	x.xx	xx
Neutral	Anxious-Neutral	xx.xx	x.xx	xx
	Neutral-Anxious	xx.xx	x.xx	xx
Total		xx.xx	x.xx	xx

Table 3 ANOVA Summary table for the effect of condition and order on infant fearfulness.

Source	*df*	MS	*F*	*p*	Effect Size
Condition	x	xx.xx	x.xx	.xxx	.xx
Order	x				
Condition x Order Interaction	x				
Error	x				

Note. MS = Mean squares, effect size = η^2 or partial η^2. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 4 ANOVA Summary table for the effect of condition and infant BI on infant fearfulness.

Source	*df*	MS	*F*	*p*	Effect Size
Condition	x	xx.xx	x.xx	.xxx	.xx
BI	x				
Condition x BI Interaction	x				
Error	x				

Note. MS = Mean squares, effect size = η^2 or partial η^2. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 5 ANOVA Summary table for the effect of condition and infant sex on infant fearfulness.

Source	*df*	MS	*F*	*p*	Effect Size
Condition	x	xx.xx	x.xx	.xxx	.xx
Sex	x				
Condition x Sex Interaction	x				
Error	x				

Note. MS = Mean squares, effect size = η^2 or partial η^2. *$p < .05$. **$p < .01$. ***$p < .001$.

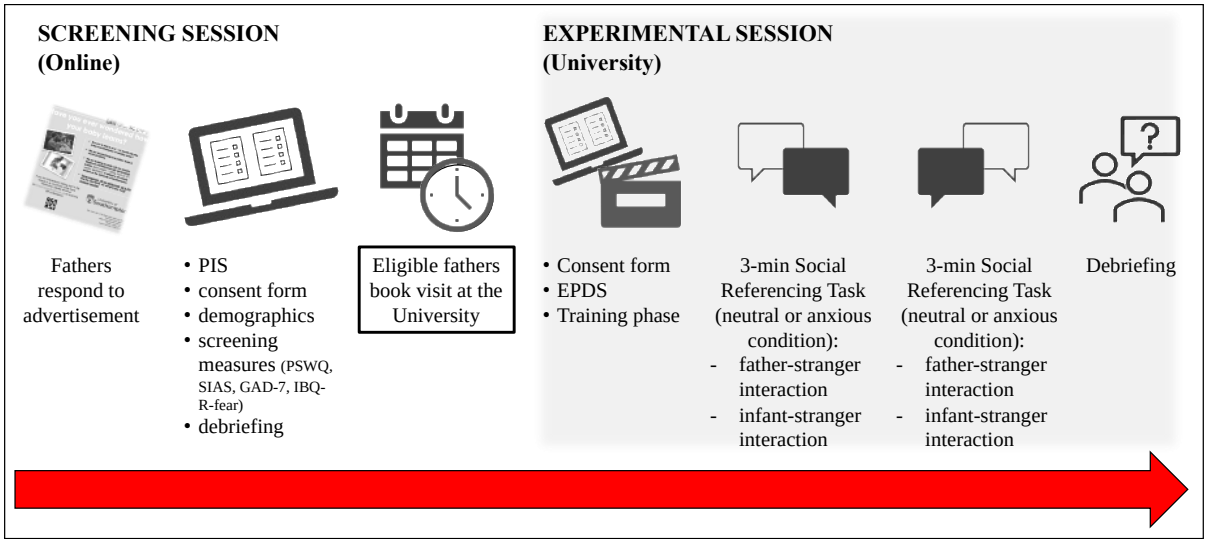

Figure 1 Overview of the study procedure.