

## Parenting sensitivity, salivary oxytocin levels and children's behavioral problems in a Portuguese sample

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**Abstract:** The present study focused on the quality of parenting behaviors (sensitivity and intrusiveness), its associations with children's levels of oxytocin (OXT), and with children's behavioral problems in the preschool context. Thirty nuclear families, including both parents and one focal child, and their preschool teachers participated in the study. Salivary OXT was collected (during two separate home visits) from children after a play task with each parent. Sensitivity and intrusiveness were coded based on the videotapes of these dyadic play interactions. Preschool teachers reported children's behavioral problems using the *Caregiver-Teacher Report Form*. Salivary OXT was collected by passive drooling, and quantified by radioimmunoassay, after extraction. Results show that only fathers' sensitivity and intrusiveness were significantly correlated with children's OXT concentrations. Both mothers' and fathers' sensitivity were negatively correlated with children's internalizing problems. Mothers' intrusiveness was positively correlated with children's externalizing problems, and fathers' intrusiveness with children's internalizing problems.

**Keywords:** Parental sensitivity; parental intrusiveness; oxytocin; behavior problems.

In recent decades, there has been a slow, but increasing effort to include fathers in the study of parenting, since most studies, although referring to parents or parenting, study mothers and their impact on child development (Cabrera et al., 2018). This increased attention can be framed by the larger socio-cultural and economic transformations regarding families and gender roles, as is the case in Portugal. For example, the changes in legislative measures promoting gender equality, family assistance, and fatherhood have contributed to a new idea of "what is a father" and his multiple roles (Wall et al., 2016). From an attachment perspective, a central dimension (not exclusive) of parenting is sensitivity (Ainsworth et al., 1974). Although several researchers highlight that sensitivity could be less salient for the father-child relationship and fathers' impact on children's social outcomes (Lucassen et al., 2011), other authors have reported that father's sensitivity, especially in the context of play activities, has a unique and significant impact on children's attachment internal model (Grossman et al., 2002).

The attachment relationship between the child and the caregivers is considered to be the evolutionarily shaped psychobiological basis of the human tendency to form social bonds, which contribute to general health (physical and mental), and well-being through the lifespan (Carter, 2014). Research on the hypothalamic neuropeptide oxytocin (OXT) suggests that it modulates responsiveness to social stimuli and is implicated in parental care, social-bonding, social affiliation, social memory, and individual differences in pro-social behavior in a broad range of mammalian species, including humans (Blos et al., 2012). OXT, which has often been called a neuro-hormone of attachment, has been suggested as having a central role in the establishment of social bonding between parents and children (Caldwell, 2017).

This study aims to contribute to the field by focusing on the quality of parenting behaviors (sensitivity and intrusiveness), studying both mothers and fathers, and its associations with children's levels of OXT measured after a dyadic play interaction. Furthermore, we have aimed to clarify the role of sensitivity/intrusiveness and the child's OXT levels in children's internalizing and externalizing behavioral problems described by pre-school teachers, in another central context for child development – the pre-school.

### Parental sensitivity and children's outcomes

The quality of parenting behaviors is crucial for children's healthy development. From an attachment-theory perspective, sensitivity and intrusiveness are key dimensions of parenting. Sensitivity, as described

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by Ainsworth, is the degree to which parents are able to detect, accurately interpret, and respond in an opportune and correct manner to their children's signals (Ainsworth et al., 1974). In contrast, intrusiveness is defined as the degree to which parents are unable to understand and respect their children's requests, desires, and independence (Egeland et al., 1993). It is expected that sensitive patterns will allow the child to feel secure and explore the environment, knowing that in case of need the caregiver will be available and will act as a safe haven (Ainsworth et al., 1974; Bowlby, 1988). Within these relationships, children co-construct not only models of the attachment figure and the relationship, but also of self, and how in general relationships should work.

Furthermore, parallel to these cognitive developments, psychobiological changes also occur in the brain and nervous system of the child. The child's stress response and social-behavior physiological systems are organized by the parents' sensitive behavior and emotional responses, with long lasting structural and functional consequences (Tabachnick et al., 2019). The integration of research from social neuroscience and social development - such as attachment theory - can foster a deeper understanding of the consequences of early-life relationships and of parent-child early interactions, informing clinical interventions as well as child-care policies.

As previously mentioned, the study of parenting has been centered on mothers for decades, and the studies that compare both mothers and fathers regarding sensitivity show different results. For example, some have reported that mothers tend to be more sensitive when compared to fathers (e.g., Hallers-Haalboom et al., 2014; Schoppe-Sullivan et al., 2006), while others have found that, like mothers, fathers are attuned and appropriately respond to their children's needs (Mills-Koonce et al., 2015). Diverse results have also been reported regarding intrusiveness, with some studies finding fathers to be more intrusive than mothers (e.g., Barnett et al., 2008), while others find no differences (e.g., Brown et al., 2007; Tamis-LeMonda et al., 2004).

It has been proposed that mothers and fathers interact differently and in specific contexts with their children (Lamb & Lewis, 2010). Grossman and colleagues (2002) have proposed that fathers may serve as a secure-base for the exploration of the social and physical environment, while mothers might act as the safe-haven, since mothers tend to be more comforting, nurturing and caring, while fathers are more associated with the contexts of play and leisure (e.g., Lamb & Lewis, 2010). Therefore, several authors have highlighted the need to study parental sensitivity beyond caregiving activities, looking to other domains more associated with fathers' interactional patterns, such as play activities (e.g., van Bakel & Hall, 2020). Studies have found that, when compared to mothers, sensitive fathers focus more on stimulating and exploratory play interactions (Lucassen et al., 2011; Mills-Koonce et al., 2015), engage more in rough-and-tumble play (StGeorge & Freeman, 2017) and encourage more risk-taking (Cabrera et al., 2014).

Despite the differences found, maternal and paternal sensitivity seem to produce similar effects in the way children develop (Brown et al., 2007). Higher levels of sensitivity are associated with, for example, children's attachment security (although the effects are stronger for mothers, van Ijzendoorn, & De Wolff, 1997) and children's cognitive development (Cabrera et al., 2007; Tamis-LeMonda et al., 2004). Conversely, greater parental intrusiveness is associated with lower academic success (Tamis-LeMonda et al., 2004), emotion regulation and language development (Cabrera et al., 2007). Parental sensitivity has also been associated with specific dimensions of children's socio-emotional development, such as externalizing and internalizing problems. Higher parental sensitivity, for both mothers (e.g., Kok et al., 2013) and fathers (e.g., Hazen et al., 2010) is associated with fewer internalizing problems. Other studies (e.g., Hazen et al., 2010), however, have found no relationship between mother's sensitivity and child internalizing problems. Similarly, higher maternal sensitivity (e.g., Campbell et al., 2007) and paternal sensitivity (e.g., Gryczkowski et al., 2010) have been associated with lower levels of child externalizing problems.

### **Parental sensitivity and oxytocin**

A vast amount of research in the last three decades has shown that OXT has a central role as a psychobiological underpinning of socio-emotional bonds, modulating important aspects of cognition, emotion, and behavior in close relationships; both in animal and human behavior (e.g., Bachner-Melman & Ebstein, 2014). It contributes to the suppression of antagonistic behavior (flight and aggression), down-regulates the stress response, increases trust and altruism, attention to social-recognition (cues fundamental to interpret others' feelings and intentions), and a number of basic biological processes common to several mammalian species (Tan et al., 2019).

A systematic review on early infancy showed that during dyadic-interactions with skin-to-skin contact, the OXT levels increased in mothers and fathers (as well as in infants) and were associated with a greater quality of their parenting behaviors (synchrony and responsiveness) (Scatliffe et al., 2019). Another systematic review, covering all childhood ages, similarly concluded that OXT promotes parental sensitivity, bonding and bio-behavioral synchrony between parents and their children (Szymanska et al., 2017). While

there are already several studies that have assessed the effects of intranasal inoculation of OXT on parents and children, research on endogenously produced OXT associated with close interactions, and specifically its association with features of the parent-child relationship, is still scarce (for a review see Torres et al., 2018). Studies with infants showed that the infant OXT system seems to react to episodes of interaction with parents and that OXT variations are correlated between infants and parents and predict parent-child behavioral synchrony (Feldman et al., 2010). At pre-school and school ages, studies support a positive association of OXT with positive social relationships and engagement with both parents, and with social reciprocity in best-friend interaction (Feldman et al., 2013). Measuring parental sensitivity (Ainsworth et al., 1974) and endogenous concentrations of OXT, Baião and colleagues (2019) assessed salivary OXT levels of Portuguese preschoolers, before and after an interaction with their mothers (fathers were not included), and its association with maternal sensitivity using the Ainsworth scales. No direct linear association was found between children's OXT levels and their mothers' sensitivity, although an interaction with children's OXT receptor gene polymorphism was found. That is, the child's OXT receptor genotype and the mother's sensitive responsiveness interacted in predicting change in child OXT concentrations from before to after the interaction. However, the study did not assess fathers. Since fathers and mothers have different styles of interaction, it is possible that there are differential effects of paternal and maternal sensitivity on the functioning of neuro-endocrine systems, such as the oxytocinergic system. Nonetheless, research on the effect of father's sensitivity on the salivary OXT response of the child is still, to our knowledge, nonexistent.

### **Oxytocin and children's behavioral adjustment**

The importance of OXT in the development and modulation of both normative and dysfunctional social behavior and cognition has been empirically demonstrated (Bachner-Melman & Ebstein, 2014). Several studies have relied on assessments of OXT levels in saliva, in conjunction with behavior, as a way to gain insight about the role of OXT in human behavior and its dysfunction (Jong et al., 2015). The studies on children have examined a range of dimensions of behavior in samples of different ages (for an extensive review, see Torres et al., 2018). Although the results are mixed, studies have reported significant associations between OXT levels and behavioral problems in children. These studies found associations between OXT in both central and peripheral fluids and depression, anxiety, and conduct problems in children. However, there is still a lack of knowledge about what interpersonal processes and socio-emotional variables determine and are associated with these variations on children's OXT levels. Additionally, research on the associations between salivary OXT and children's behavioral problems suggest it may represent a useful biomarker of risk for psychopathology in children (Rutigliano et al., 2016; Torres et al., 2018).

Still, many questions remain open regarding: (a) how to adequately measure endogenous levels of OXT; (b) what are the specific bio-behavioral feedback processes, between parents and children, that regulate the production of OXT; (c) what are the observable behaviors and developmental outcomes associated with individual differences in the OXT system response (for a review of present issues with OXT studies in children, see Torres et al., 2018). In the present study, the authors aimed to address issues (a) and (c), firstly by using a previously developed criterion to select the best possible timing and context of saliva sampling for a more reliable OXT measurement (see Torres et al., 2022), and by assessing the observed sensitivity/intrusiveness of both parents and children's behavior problems.

### **Aims of the study**

This study aims to explore the associations between the quality of observed mother's and father's parenting behaviors (i.e., sensitivity and intrusiveness) and children's OXT levels measured after a dyadic play interaction with each parent; and children's internalizing and externalizing problems reported by their pre-school teachers. This study thus uses a multi-methods approach employing observational and self-report measures, and multi-informants – parents and teachers – increasing the validity of the study. This is, to our knowledge, the first study assessing the association of fathers' sensitivity and intrusiveness during a dyadic play interaction with children's OXT levels.

## **METHOD**

### **Participants**

Thirty nuclear Portuguese families (30 mothers, 30 fathers, and 30 focal children), and 30 teachers participated in the study. Mothers were between 32-51 years old ( $M = 39.1$ ,  $SD = 5.3$ ), and fathers 33-52 years old ( $M = 40.3$ ,  $SD = 5.3$ ). Mothers' education ranged from high-school (21.4%) to a university degree (78.6%), while fathers' education ranged from primary education, (18.5 %), high-school (37%), and 44.5% with a university degree. Eighty percent of the mothers and 90% of the fathers worked full-time outside of

the home. All children (17 girls; Age:  $M = 60.9$ ,  $SD = 9.5$  months) attended preschool classrooms full time; 87.8% had siblings and of those, 65.4% were first born. Thirty preschool teachers (responsible for the classrooms attended by the participating child) had a university degree in child education (as it's mandatory by law in Portugal).

The criteria for inclusion in the study were: children needed to attend pre-school classrooms, and be at least ~36 months old, show no evidence of major neurodevelopmental disorders, been born at term, be living in bi-parental families.

### **Instruments and Procedures**

All parents and teachers provided written informed consent, and children were asked if they wanted to participate in a game prior to data collection. All procedures were approved by the Research Ethics Committee of the University of ISPA - Instituto Universitário de Ciências Psicológicas, Sociais e da Vida and conducted in accordance with the ethical principles of psychologists and code of conduct of the American Psychological Association. Home visits were scheduled with each parent separately, on different days, and counterbalanced across participants. The intervals between home visits were on average 9.5 days (minimum of 3, maximum of 15 days). During these visits, both parents' sensitivity and intrusiveness, as well as saliva samples were collected. Pre-school teachers reported on children's behavioral problems (children attended the same classroom, with the same pre-school teacher, for at least 6 months).

**Parenting sensitivity and intrusiveness.** Dimensions of parenting quality, i.e., sensitivity and intrusiveness, were assessed through a semi-structured play activity based on the *three boxes procedure* (NICHD Early Child Care Research Network, 1999). The child and parent were presented with three numbered bags, each with a toy inside, and were told that the goal was for the child to play with each bag for a total of 15 minutes. Participants were told to divide the time between the toys as they saw fit, no instruction was given regarding whether or not the parent should play with the child. The only rule given was that they should play with the toys in numerical order. Different sets of toys were used for mother/father-child interactions to maximize child interest. Both sets were selected to be age appropriate, but challenging and interesting for the child, and to offer dyads the opportunity to engage in different types of play.

For this study, the child was sat on the parent's lap during the task, in order to promote skin-to-skin contact, which has been shown in previous studies, as mentioned, to be associated with the functioning of the OXT system both in parents and children.

The activity was video-recorded and later codified in terms of sensitivity and intrusiveness by four previously trained independent coders (two of them certified). Inter-rater agreement before data collection/coding achieved good inter-rater reliability (sensitivity: ICC = .89; intrusiveness: ICC = .91). Sensitivity was assessed with the *Ainsworth sensitivity rating scales* (Ainsworth et al., 1974), measuring the accessibility, attention, interpretation and response of the parent to the child's signals. Intrusiveness was coded with the *Erickson rating scales* and refers to the degree to which the parent disregards and interferes with the child's autonomy, wishes, interests or behaviours (Egeland et al., 1990).

### **Salivary OXT**

This study is part of a larger project in which a total of seven samples of saliva were collected from each child, in order to estimate the reliability of salivary oxytocin measurements in different contexts (these results were presented in another paper, see Torres et al., 2022). In the present study, only two of those samples showing the highest reliability - those collected after playing with parents - will be analyzed. Saliva samples collected after play had an ICC of .68, while before play the reliability was .60. As stated in the above-mentioned paper, this is possibly because the synchrony between OXT levels in the brain and in peripheral fluids such as saliva occurs after emotionally intense moments, such as stressful and hedonic events (for a meta-analysis, see Valstad et al., 2017). It is crucial that more reliable measures are used in order not to increase the random error of measurement, and risk not finding significant statistical effects when they exist in the population (Type-I error). This is especially important in studies where the samples are not very large (less than 100 subjects), but also in all studies in order to estimate correct effect sizes of the phenomena.

The two samples used in the present study were collected by the researchers, (strangers to the child), during the two home-visits, 15 minutes after the dyadic play task described above. A minimum of 3.5ml of saliva was collected for each sample. All the requirements for saliva collection had to be met prior to collection. Samples were always collected between 5-6 pm to minimize potential variability related to circadian rhythms.

After collection, the saliva was immediately stored in a freezer (-20° C), as per standard procedures. Samples were initially frozen at the families' homes and then transported in a portable freezer to the lab, where they were stored at -80° C until being sent for analysis in an outsource service (RIAGnosis, Munich, Germany). Transport was made in solid carbon at an average temperature of -80° C. Samples were collected by passive drooling to a 5 ml plastic polypropylene tube. In a previous study, measurements from passive drool saliva samples provided more accurate estimations of hormonal levels, even after intermediary processing steps, including freezing, thawing, and centrifugation (Robles et al., 2013).

Salivary OXT was quantified by radioimmunoassay (RIAGnosis, Munich, Germany), after extraction. For each sample, 300 ul of saliva was evaporated (SpeedVac, ThermoScientific Inc, Waltham, MA, USA), and 50 ul of assay buffer was added followed by 50 ul antibody (raised in rabbits against OXT). After a 60-min pre-incubation interval, 10 ul 125I-labeled tracer (PerkinElmer, Waltham, MA, USA) was added and samples were allowed to incubate for 3 days at 4° C. Unbound radioactivity was precipitated by activated charcoal (Sigma-Aldrich, St Louis, MO, USA). Under these conditions, an average of 50% of total counts are supposed to bind with < 5% non-specific binding. The detection limit of this assay was determined to be in the 0.5 pg/sample range, depending on the age of the tracer, with typical displacements of 20–25% at 2 pg, 60–70% at 8 pg, and 90% at 32 pg, of the standard neuropeptide. In this study, nine (4.4%) of the quantified samples were below the detection range and for this reason were excluded from further analysis. Cross-reactivity with arginine vasopressin (AVP), ring moieties and terminal tripeptides of both OXT and AVP and a wide variety of peptides comprising 3 (-melanocyte-stimulating hormone) up to 41 (corticotrophin releasing factor) amino acids are < 0.7% throughout. The intra and inter-assay variabilities are estimated in < 10%. Saliva samples were analysed in different batches; however, all samples from an individual were always assayed in the same batch. Serial dilutions of saliva samples containing high levels of endogenous OXT run strictly parallel to the standard curve indicating immuno-identity.

**Children's behaviour problems.** Preschool teachers answered the Caregiver-Teacher Report Form (C-TRF) (Achenbach & Rescorla, 2000), assessing children's behavioural, emotional, and social problems. The Portuguese version (Achenbach et al., 2014) has two global scales that were derived from factor analysis: internalizing problems (32 items) referring to difficulties of an individual nature with symptoms that pertain only to the child's behaviour (e.g., has sudden changes in mood or feelings), and encompassing the dimensions of emotion reactivity, anxiety/depression; somatic complaints; withdrawal; and externalizing problems (34 items), which refers to difficulties and conflicts with others, with symptoms that concern child's behaviour towards peers and teachers (e.g., is cruel, abusive or bad to others), englobing the dimensions of attention problems, and aggressive behaviours. Teachers rated each item, considering how true each statement was for the child's behaviour within the past 2 months, using a three-points Likert scale (0 – not true; 1 – somewhat true; 2 – very true). Test-retest reliability for all the scales used in this study was > .75 (Achenbach & Rescorla, 2000).

### Plan of analysis

First, statistical descriptive analyses of all variables in study were performed. Secondly, differences between fathers' and mothers' sensitivity and intrusiveness scores were tested, as well as the difference between fathers' and mothers' sensitivity and intrusiveness for girls and boys. In addition, sex differences between children's levels of OXT and behavioral problem scores were tested. Finally, a series of correlation analyses were performed among all variables in study. All test statistics were non-parametric due to the sample size. In the computation of non-parametric correlations, a bootstrap method of estimation was used to increase the accuracy of the coefficients.

### RESULTS

Preliminary descriptive analyses were performed for parenting quality, the child's OXT concentrations after parent-child play activities, and the child's behavioral problems. Results are presented in Table 1.

**Table 1.** Descriptive statistics of the variables in study

	Min	Max	M	SD
Parenting quality				
Mother's sensitivity	3.50	7.50	5.33	1.05
Father's sensitivity	4.50	7.50	5.46	.75
Mother's Intrusiveness	1.50	6.00	3.57	1.23
Father's Intrusiveness	1.50	4.00	2.89	.75
Child's OXT <sup>1</sup>				
Child OXT after playing with Mother	.35	1.92	1.09	.38
Child OXT after playing with Father	.34	1.89	.99	.39
Child's behavioral problems				
Internalizing problems	.00	17.00	6.59	4.53
Externalizing problems	.00	35.00	13.15	9.74

<sup>1</sup> OXT concentration, measured in Picograms per millilitre (pg/mL)

Differences between fathers' and mothers' sensitivity and intrusiveness scores were tested using the *Willcoxon* signed rank test. Although no significant differences were found for sensitivity ( $z = -.99, p = .33$ ), a significant difference was found for intrusiveness ( $z = 2.35, p = .02$ ), with mothers scoring higher than fathers. Differences between OXT concentrations after playing with the father and after playing with the mother were also tested, using the *Willcoxon* signed rank test, no significant differences were found ( $z = -.56, p = .61$ ).

To test the relationship between all variables in study, associations were tested using Spearman's Rho correlations. In addition, the percentile bootstrap method with 1000 samples was used to achieve more reliable coefficients (Bishara & Hittner, 2016). Results are presented in Table 2. In order to assess the possible effect of the synchrony of the OXT response after playing with both parents, a composite variable was computed by averaging the two measures of children's OXT levels after playing with the father and with the mother.

**Table 2.** Correlations between parenting quality, OXT evoked after parent-child interaction, and children's behaviour problems

	1	2	3	4	5	6	7	8	9
1.Mother's sensitivity	-	.36*	-.91**	-.19	.04	-.19	-.06	-.31*	-.27
2.Father's sensitivity			-.34*	-.76**	.25	.47*	.34*	-.42*	-.27
3.Mother's Intrusiveness				.14	-.06	.12	.03	.27	.33*
4.Father's Intrusiveness					-.42*	-.46**	-.53**	.36*	.16
5.Child OXT after playing with Mother						.62**	.92**	-.04	-.18
6. Child OXT after playing with Father							.88**	-.18	-.31*
7. Composite OXT after playing with Father+Mother								-.17	-.33*
8. Child's Internalizing									.46**
9.Child's Externalizing									-

\* $p < .05$ ; \*\* $p < .01$

Fathers' sensitivity was positively and significantly correlated with children's OXT concentrations after the dyadic play activity, and fathers' intrusiveness was significantly negatively associated with OXT. Mothers' sensitivity and intrusiveness were not correlated with the children's OXT. In addition, children's OXT levels after playing with fathers were positively and significantly correlated with externalizing behaviours, but not with internalizing problems. That was not the case for mothers. Finally, the composite measure of OXT after playing with the father and mother was negatively and significantly associated with the child's externalizing behaviors but was of the same magnitude as the OXT after playing only with the father.

For both mothers' and fathers' sensitivity, scores were negatively and significantly associated with children's internalizing problems. Mothers' intrusiveness scores were positively and significantly correlated with children externalizing problems, whereas fathers' intrusiveness was positively and significantly correlated with children internalizing problems.

## DISCUSSION

This study aimed to assess the association between mothers' and fathers' parenting behaviors (sensitivity and intrusiveness), and the salivary OXT levels of their children, as well as with children's internalizing and externalizing problems as assessed by their preschool teachers. This is, to our knowledge, the first study

assessing the association of both mothers' and fathers' sensitivity and intrusiveness during a dyadic play interaction, with children's salivary OXT levels. The literature on parenting tends to emphasize the differences in behaviors and contexts of interaction between fathers and mothers, highlighting the context of play, challenge and physical interaction (Cabrera et al., 2000; Lamb & Lewis, 2010), and their differential effects on child socio-emotional development (e.g., Grossman et al., 2002). This makes it important to investigate both parents when considering psychobiological processes, such as the children's OXT system association with socio-emotional interactions.

Our results show different effects of fathers' and mothers' sensitivity: while mothers' sensitivity and intrusiveness had no association with children's OXT levels, fathers' sensitivity and intrusiveness were both associated with children's OXT levels after play. Fathers' sensitivity was correlated with higher OXT levels, while intrusiveness had the opposite effect, being significantly associated with lower levels of OXT. A previous study with Portuguese children and their mothers also found no significant direct effect of mothers' sensitivity during play on children's OXT. However, a significant effect was found only when mother sensitivity was moderated by a genetic variation in the child's OXT receptor (Baião et al., 2019). Our study, which used a quite similar play procedure and a comparable measure of maternal sensitivity, partially replicated these results as to the absence of a direct association of maternal sensitivity and intrusiveness with the salivary OXT levels of the child. In contrast, the fact that in our study fathers' sensitivity and intrusiveness were both significantly associated with children's OXT levels, suggests the hypothesis that children's OXT levels after play might be sensitive to specific factors that are triggered by fathers' interaction contexts. Since the present design is correlational, causality inferences cannot be made. However, previous research on the developmental effects of fathers' sensitivity in playing has shown a specific causal effect of fathers' sensitivity in playing with developmental outcomes that are linked with the OXT system. One of these outcomes is the attachment system of the child, which has been shown to be associated with OXT (e.g., Carter, 2017). Previous longitudinal research on attachment has found that fathers' sensitivity during play had a specific and unique effect on the children's attachment and emotional development, from toddlerhood to adolescence, namely on their internal attachment model (Grossman et al., 2002). While mothers' play sensitivity in early childhood was not associated with children's security of attachment at later ages, father sensitivity in play predicted security at ages 10 and 16.

Additionally, we found that both fathers' and mothers' sensitivity and intrusiveness were directly associated with behavioral problems in the preschool settings, as reported independently by the children's teachers. Previous research has reported the association of maternal sensitivity with children's internalizing problems including large scale population cohort prospective longitudinal studies (Kok et al., 2013). Our results are in line with this previous research on the effect of mothers' sensitivity on behavioral problems, and further contributes to validate the assessment of sensitivity used in our study. The research on fathers' sensitivity association with behavioral problems is less developed than on mothers'. However, a recent meta-analysis (Rodrigues et al., 2021) found a great range of variability in the results and very small overall effect sizes for both internalizing and externalizing problems. In contrast with our results, the meta-analysis found a significant effect of paternal sensitivity on externalizing but not on internalizing problems. The disparity in results might have to do with methodological differences in the assessment of both father sensitivity and behavioral problems. In our study, we have used reports of children's behavioral problems from independent informers, the teachers, which makes our results less vulnerable to same-informant bias and is not always the case in all studies. Finally, a very specific and negative association was found between OXT levels after playing with the father and externalizing problems of the child, but not internalizing. In conjunction with the association between fathers' sensitivity and children's OXT levels, this result might suggest a psychobiological path from fathers' sensitivity in play to externalizing problems of the child, which may include OXT levels in the child as an underlying biological link between the two. That is, it is possible that paternal sensitivity may contribute to a more effective OXT system functioning for children, which in turn will manifest behaviorally in a more adapted social behavior in school. However, at the moment, the lack of other studies about paternal sensitivity and children's OXT levels makes it difficult to present clear conclusions about the precise mechanisms involved.

### Limitations

Some limitations should be acknowledged. Firstly, our sample size was relatively small and composed of biparental middle-class families only, which makes our results preliminary and in need of replication with bigger and more diverse samples to be generalizable to the population. Additionally, our sample was composed of normally developing children, without development disorders or psychopathological diagnosis. Another limitation is that in this study we could not assess causality in the relation between OXT levels and parental behavior during play: 1) Although we collected several saliva samples before the dyadic play, as stated above, none of those samples collected before play reached acceptable levels of reliability

(see also Torres et al, 2022, for extensive discussion of this topic); 2) In order to assess the hypothetical causal effect of parental sensitive/intrusive behavior in the variation of OXT, before and after play, an experimental or quasi-experimental comparative study with a control group would be necessary. Finally, in terms of OXT measurement, our findings apply to (1) the specific method of saliva sampling used (passive drooling) with immediate freezing of the saliva at  $-20^{\circ}\text{C}$ ; and (2) to the method of quantification we used, radioimmunoassay, including prior extraction.

To understand the precise interactive mechanisms between parents and children that contribute to individual differences in OXT levels, and to differences between mothers and fathers, future studies should focus on analyzing more in-depth micro-sequences of interactive behaviors, as well as gender-typical behaviors. Additionally, our study has focused on the OXT levels found in saliva after a playful, hedonic, event with parents. Since it is known that the OXT system is implicated in other types of emotional events, such as reunion with the mother after separation, as well as being highly responsive to stress, future studies should assess non-play emotional situations.

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### CRedit AUTHORSHIP CONTRIBUTION STATEMENT

**Nuno Torres:** Conceptualization; Data Curation; Formal analysis; Investigation; Methodology; Writing - Original Draft; Writing - Review & Editing. **Lígia Monteiro:** Formal analysis; Writing - Original Draft; Writing - Review & Editing. **Carolina Santos:** Formal analysis; Writing - Original Draft; Writing - Review & Editing.

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