# Storytelling increases oxytocin and positive emotions and decreases cortisol and pain in hospitalized children

Guilherme Brockington[a,1], Ana Paula Gomes Moreira[b], Maria Stephani Buso[c], Sérgio Gomes da Silva[d,e,f], Edgar Altszyler[g], Ronald Fischer[h,i], and Jorge Moll[h,j]

[a]Center of Natural and Human Sciences, Federal University of ABC, São Paulo 09210-580, Brazil; [b]Department of Pedagogy, University of Mogi das Cruzes, São Paulo 08780-911, Brazil; [c]Department of Psychology, Federal University of São Paulo, São Paulo 04021-001, Brazil; [d]Núcleo de Pesquisas Tecnológicas, University of Mogi das Cruzes, São Paulo 08780-911, Brazil; [e]Hospital do Câncer de Muriaé, Fundação Cristiano Varella, Minas Gerais 36880-000, Brazil; [f]Centro Universitário UNIFAMINAS, Minas Gerais 36888-233m, Brazil; [g]Instituto de Investigación en Ciencias de la Computación, Consejo Nacional de Investigaciones Científicas y Técnicas, Universidad de Buenos Aires, Buenos Aires C1053, Argentina; [h]Cognitive Neuroscience Unit, D'Or Institute for Research and Education, Rio de Janeiro 22.281-100, Brazil; [i]School of Psychology, Victoria University of Wellington, Wellington 6140, New Zealand; and [j]Scients Institute, Palo Alto, CA 94306

Edited by Emily A. Holmes, Uppsala University, Uppsala, Sweden, and accepted by Editorial Board Member Michael S. Gazzaniga April 12, 2021 (received for review August 31, 2020)

**Storytelling is a distinctive human characteristic that may have played a fundamental role in humans' ability to bond and navigate challenging social settings throughout our evolution. However, the potential impact of storytelling on regulating physiological and psychological functions has received little attention. We investigated whether listening to narratives from a storyteller can provide beneficial effects for children admitted to intensive care units. Biomarkers (oxytocin and cortisol), pain scores, and psycholinguistic associations were collected immediately before and after storytelling and an active control intervention (solving riddles that also involved social interaction but lacked the immersive narrative aspect). Compared with the control group, children in the storytelling group showed a marked increase in oxytocin combined with a decrease in cortisol in saliva after the 30-min intervention. They also reported less pain and used more positive lexical markers when describing their time in hospital. Our findings provide a psychophysiological basis for the short-term benefits of storytelling and suggest that a simple and inexpensive intervention may help alleviate the physical and psychological pain of hospitalized children on the day of the intervention.**

narratives | storytelling | oxytocin | cortisol | LIWC

We are all storytellers. From the bards and troubadours of the Middle Ages to the most recent Hollywood blockbuster, humans are exceptionally attracted to telling and listening to stories. Storytelling is culturally ubiquitous (1, 2). In fact, our taste for narrative has likely played a critical adaptive role in human society (3–5). The act of telling stories has been shown to be a central element for establishing human connections and influencing subjective emotions in both the storyteller and the audience (1, 6, 7).

From a psychological standpoint, stories allow us to make meaning of our world (8). Furthermore, storytelling helps us navigate our social world by turning the continuum of lived events into a coherent and organized narrative, despite life's emotional peaks and valleys (9, 10), and helps to simulate possible social realities (11, 12).

Recent research into the universal human interest in narratives and storytelling provides insight into possible mechanisms. One main hypothesis is derived from a process known as "narrative transportation," a dynamic and complex interaction between language, text, and imagination which creates a state of cognitive and emotional immersion that deeply engages listeners in the world of the narrative (13–15). Stories invite readers or listeners to immerse themselves in the portrayed action and thus lose themselves for the duration of the narrative. During this process, the world of origin becomes partially inaccessible to the listener, marking a separation in terms of the "here" and the "there," the "now" and the "before," the narrative world of the story and the world of origin. Current psychological and neuroscientific evidence supports the basic premises of this transportation process (16, 17) and its plausible origins based on evolutionarily relevant preadaptations involving mirror neuron systems, conversational language structures, metaphor processing, and imagination. Furthermore, cognitive theories suggest that stories facilitate and enable mental simulations, thereby facilitating mental models that people use to simulate social realities. Mar and Oatley (11) argue that narratives offer models or simulations of the social world via abstraction, simplification, and compression, which then allow for vicarious learning of social realities through the experience of fictional characters. These narrative transportations and mental simulations can help reframe personal experiences, broaden perspectives, deepen emotional processing abilities, increase empathy, and regulate self-models and emotional experiences (17–19).

These various lines of inquiry provide some rationale for using storytelling as a form of behavioral intervention. Indeed, it is not uncommon to find storytelling programs at hospitals all over the world. However, the effect of storytelling is mainly anecdotal, and its impact on children's well-being and physiology is still insufficiently understood (20). Here, we present evidence that storytelling can positively influence both psychological and physiological variables in

PSYCHOLOGICAL AND COGNITIVE SCIENCES

## Significance

**Storytelling is a unique human skill, yet we know little about its physiological and psychological impact. This study provides evidence of the biomarker changes and beneficial effects of storytelling in children admitted to an intensive care unit. We found that, compared with an active control condition, one storytelling session with hospitalized children leads to an increase in oxytocin, a reduction in cortisol and pain, and positive emotional shifts during a free-association task. These multimodal findings support evolutionary theories of storytelling and demonstrate its physiological and psychological effects under naturalistic stress conditions. These important clinical implications affirm storytelling as a low-cost and humanized intervention that can improve the well-being of hospitalized children.**

Author contributions: G.B. and A.P.G.M. designed research; M.S.B. performed research; G.B., S.G.d.S., E.A., and R.F. analyzed data; and G.B., A.P.G.M., R.F., and J.M. wrote the paper.

The authors declare no competing interest.

This article is a PNAS Direct Submission. E.A.H. is a guest editor invited by the Editorial Board.



[1]To whom correspondence may be addressed. Email: brockington@ufabc.edu.br.

This article contains supporting information online at https://www.pnas.org/lookup/suppl/doi:10.1073/pnas.2018409118/-/DCSupplemental.

Published May 24, 2021.

hospitalized children, even within highly challenging settings such as intensive care units (ICUs).

Being admitted to hospitals inflicts significant trauma on children (21). Hospitalizations abruptly remove children from their daily routines, both at home and at school. In addition to experiencing the difficulties and discomforts associated with their illnesses, this sudden disruption can cause disturbances that impact children's lives in dramatic ways. These disturbances may be so severe that children develop unhealthy or painful habits that negatively affect them after discharge from the hospital (22, 23). Removed from their core social networks of friends and families and placed in highly unfamiliar surroundings, children are deprived of the social elements that bring them comfort and security during trying and painful times. Such factors create a stressful situation that may interrupt their development and often cause affective and cognitive impairments, even after the hospitalization event (24–26).

Given the centrality of storytelling for building and maintaining human connection (as indicated by anthropological literature), and the noted psychological effects of storytelling for creating meaning in lived experiences and narratives, we propose and test whether storytelling can mitigate the suffering caused by these conditions.

Thus, we hypothesize that storytelling induces children to feel transported to another possible world, one that is distant and different from the threatening, aversive and tedious environment of the ICU. As a result, the adverse physiological and psychological reactions experienced during their ICU stay should be temporarily reduced.

To comprehensively capture both the psychological and physiological effects of storytelling, we focus on physiological biomarkers, standardized psychometric tests, and psycholinguistic indicators. To identify biomarkers, we consider storytelling's central role as an effective intervention for increasing empathy, reinforcing human connection, and decreasing stress. Two promising biomarkers that provide insight into these mechanisms are oxytocin and cortisol.

Converging evidence strongly implicates oxytocin in the empathic processes (27) of establishing and maintaining positive interpersonal behavior, modulating trust in social interactions, and reducing stress (28). Studies have shown that oxytocin affects the establishment of social bonds. Researchers have demonstrated a direct link between oxytocin and empathy, emotional processing (and, by extension, a reduction in mood disorders), the lessening of fear responses, and the capacity to infer other people's emotional states (29, 30). Cortisol is a hormone secreted by the adrenal glands that plays a central role in the human stress response (31). In response to a stressor, either real or imagined, the body activates a complex and dynamic lifesaving system to restore homeostasis. During this process, the action of the hypothalamic–pituitary–adrenal axis is a central determinant (32), and cortisol is one of the main effectors. The ease of measurement and the high specificity/sensitivity of the cortisol response makes it one of the most useful physiological markers. Therefore, we predict that storytelling leads to a reduction in cortisol and an increase in oxytocin poststorytelling compared to before and compared to an active control intervention. In combination with the physiological changes, we also expect that subjective ratings of pain will decrease in the storytelling condition compared to an active control condition. Furthermore, the meaning-making content of a story is expected to change the linguistic associations that children form about the hospital environment.

In summary, the human connection and meaning-making induced by storytelling will lead to changes in biomarkers, pain scores, and psycholinguistic associations with the hospital environment.

To test our hypotheses, we recruited 81 children hospitalized in ICUs, randomized into two intervention groups: 1) Storytelling ($n = 41$) and 2) Riddle ($n = 40$). These children presented quite similar clinical conditions, respiratory problems (e.g., asthma, bronchitis, and pneumonia) being the most common. Sedated children and those who had neurological problems that would prevent them from taking part in the interventions were not included in the study. We randomly assigned each child to one condition (story or riddle). In the story condition, children were given the option to choose among eight stories typically found in children's literature. All of the selected stories were light-hearted or amusing (*SI Appendix* provides an emotion-word analysis of the stories as well as ratings of those stories). At any moment, a child could change the story or ask for a particular story to be retold. We excluded stories that were deemed to be too emotionally loaded by a group of 10 seasoned storytellers who did not participate in this research. We recruited six storytellers with more than 10 y of experience in hospitals to read the story selected by the child for 25 to 30 min. For the Riddle group, the same storyteller played a riddle game for 25 or 30 min during which the child had to solve an amusing question posed by the storyteller ("What is it?" "Something you don't eat that's good for eating?" "What opens all the doors without ever going in or out of them?").

This active control condition was designed to carefully control social interactions and attention, which were very similar to the storytelling condition but lacked the narrative immersion provided by the stories. Children in both groups had a saliva sample collected at the beginning of the study (1 min before the intervention) and another immediately after the intervention. They completed a standardized pain scale to assess how much pain they felt before and after the intervention. All children were also asked to complete a free-association word quiz after the intervention. They were shown seven cards with illustrations of a nurse, hospital, doctor, sick person, book, pain, and medicine (see *SI Appendix* for the stimulus material). Their associations were audio-recorded and later transcribed.

## Results

**Oxytocin and Cortisol Levels and Pain Scale of Hospitalized Children.** Descriptive information on all variables is presented in Table 1. We tested our model using two-way analysis of covariance (ANCOVA) controlling for age, gender, and time of sampling and mixed-effects models using both parametric and log-linear models. The results converge, and here we present the ANCOVA results and effect sizes (full results for all additional analyses are presented in *SI Appendix*). After controlling for age, gender, and time of sampling, we found significant interactions between the prepost-test measurement and intervention group [oxytocin: $F_{(1,\ 67)} = 25.92$, $P < 0.001$; cortisol: $F_{(1,\ 67)} = 14.22$, $P < 0.001$; pain: $F_{(1,\ 67)} = 7.06$, $P < 0.05$], as shown in Table 2. In line with our predictions, we observed that storytelling was associated with an increase in salivary oxytocin levels (d = 1.26) and a reduction in salivary cortisol levels (d = −0.43) and pain scale (d = −0.97) at time 2 (Fig. 1*A*). Despite the fact that preintervention cortisol levels were higher in children from the Storytelling group (which we interpret as being a random occurrence) compared to the Riddle group ($P < 0.05$), children in both conditions (Storytelling and Riddle) showed reduced cortisol responses postintervention ($P < 0.05$). When testing each intervention's differential effect (calculating

**Table 1. Sample description**

| | Storytelling | Riddle | Total |
|---|---|---|---|
| *n* | 41 | 40 | 81 |
| Age, years | 7.02 | 7.1 | 7.06 |
| SD age, years | 2.14 | 2.34 | 2.23 |
| Mean time of the day | 3:25 p.m. | 3:16 p.m. | 3:20 p.m. |
| Females, No. | 22 | 19 | 41 |
| % total | 54 | 48 | 51 |

**Table 2. Descriptive information**

| | Stories | | Riddles | | | |
|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | Pre–post intervention [$F(1, 67)$, $P$] | Effect size ($\eta^2$) |
| Oxytocin | 38.6 (22.2) | 354.0 (144.0) | 35.7 (19.2) | 181.0 (130.0) | 25.92, <0.001 | 0.269 |
| Cortisol | 1.15 (0.35) | 0.47 (0.27) | 0.91 (0.36) | 0.59 (0.29) | 14.22, <0.001 | 0.155 |
| Pain score | 3.85 (1.75) | 1.15 (0.36) | 3.72 (1.97) | 2.18 (1.45) | 7.06, <0.01 | 0.091 |

Data for stories and riddles are presented as mean (SD).

post values – pre values), we observed a significant difference between the two groups (Fig. 1*B*). Storytelling increased salivary oxytocin levels [$t(79) = 5.34$, $P < 0.001$] and reduced salivary cortisol levels [$t(79) = -3.87$, $P < 0.001$] and pain scores [$t(79) = -2.89$, $P = 0.005$] in comparison to the riddle intervention. These results were not influenced by age, gender, or time of sampling in hospitalized children (see *SI Appendix* for further analyses).

**Linguistic Inquiry and Word Count.** We used Linguistic Inquiry and Word Count (LIWC) (33, 34) to quantify the presence of emotional elements in the free-word-association task. LIWC is a widely used text analysis tool that counts words related to several psycholinguistic categories. These categories contain linguistic dimensions (e.g., pronouns and prepositions), psychological processes (e.g., negative emotion, positive emotion, and anxiety), personal concerns (e.g., home, money, and religion), and spoken categories (e.g., assent and fillers). Each LIWC category is composed of a dictionary word list. The positive emotions category contains words such as "happy," "pretty," and "friend," while the negative emotions category includes words such as "hate," "worthless," and "enemy." Given the short length of the task answers, we used binary measures. For example, we decided that an answer contains positive emotions if it includes at least one word from the positive emotion category. For the present analyses, we used the positive emotions and the



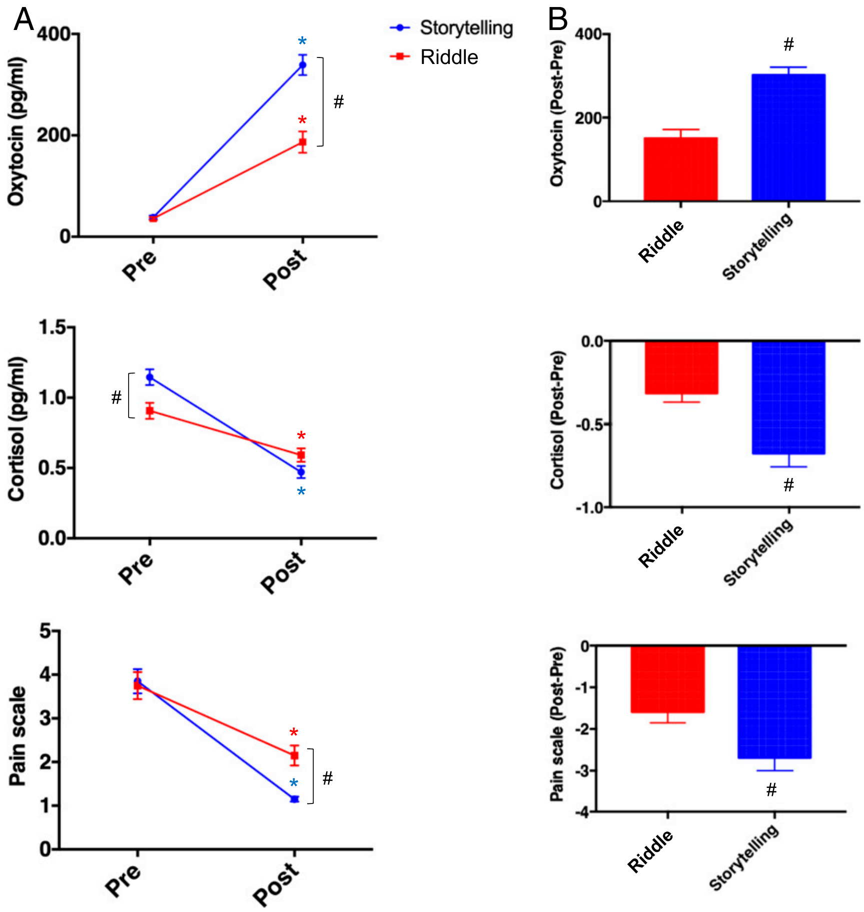


**Fig. 1.** (*A*) Oxytocin and cortisol levels and pain scale of children in pre- and postintervention moments comparing storytelling and riddle interventions ($n$ = 40 for Riddle group and $n$ = 41 for Storytelling group). Significant difference compared with preintervention moment* or group#. (*B*) Delta effect of storytelling and riddle interventions on oxytocin and cortisol levels and pain scale in children ($n$ = 41 or 40 for each variable and group). Significant difference between groups is indicated by # and significant effects are indicated by *.

negative emotions categories of the Brazilian Portuguese version of LIWC (35).

**Free-Association Task.** Sentiment analysis of the postintervention free word association task for both groups is shown in Fig. 2. Fig. 2, *Top* shows the percentage of children's positive emotion words. Fig. 2, *Bottom* displays the percentage of negative emotion words. The Storytelling group showed a higher proportion of positive emotions in the free-association task as compared to the Riddle group for the nurse (Cramér's V = 0.38, $P < 0.001$), hospital (Cramér's V = 0.36, $P = 0.0012$), and doctor stimulus pictures (Cramér's V = 0.38, $P < 0.001$). The Storytelling group also reported a lower proportion of negative emotion words than the Riddle group for the hospital stimulus (Cramér's V = 0.42, $P < 0.001$).

Figures displaying the individual data points in addition to mean distributions are included in *SI Appendix*.

## Discussion

Our results revealed that both interventions involving positive social interactions were associated with increased oxytocin levels in hospitalized children. However, those assigned to the Storytelling group presented an increase in oxytocin levels twice as large as children in the Riddle group while also reporting marked decreases in subjective pain scores. Our results point to the important link between the molecular bases of social cognition and the well-being of hospitalized children, with oxytocin playing a vital role in this connection. Recent studies using intranasal application reveal that an increase in oxytocin resulted in an attenuation of the psychosocial stress response, causing a lessening of anxiety and a growing sensation of calm (36) as well as an increase of trusting behavior during social interaction (37, 38). These patterns are paralleled in our experiment in the changed linguistic behavior after the intervention, with children mentioning more positive words in the free association task. The significant increases in positive emotions used by the children in the Storytelling group occurred when asked about central social figures in the ICU (Nurse or Doctor) and when being asked about the larger category of the hospital. For instance, for the children in the Riddle group, responses included the following: Nurse – "a crabby lady who gives me nasty-tasting medicine"; Doctor – "a cruel person who pokes me with a needle"; Hospital – "a bad place where I go when I'm very sick."

In contrast, the children in the Storytelling group were more likely to say: Nurse – "a person who helps us get well and go home"; Doctor – "someone who takes care of me"; Hospital – "a place where I stay until I feel better." At the same time, the children from the Storytelling group reported fewer negative emotion words than the children from the Riddle group. At the experimental level, we can interpret the increase of oxytocin and change in the children's affective states as evidence that children felt more comfortable and socially connected in the hospital context and more secure in their dealings with doctors and nurses after participating in storytelling interventions.

Both groups experienced a reduction of the cortisol hormone after the intervention. However, this reduction was twice as large among children in the Storytelling group compared with those in the Riddle group. Both interventions had the same degree of

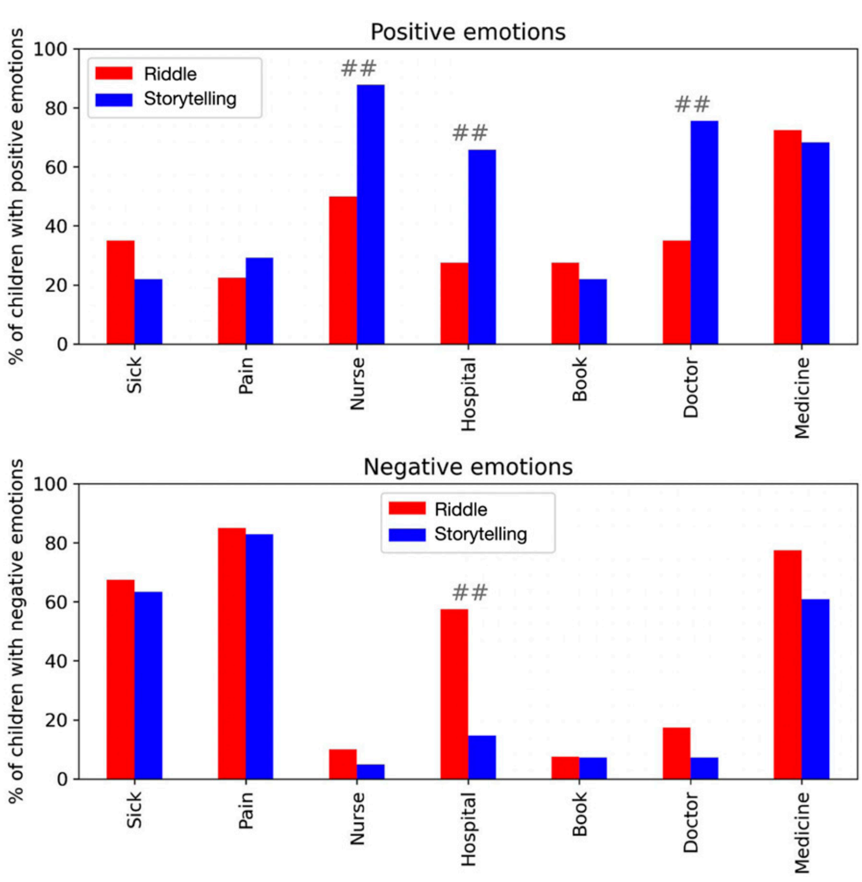


Fig. 2. Sentiment analysis of postintervention free-association task. (*Top*) The percentage of children with positive emotions. (*Bottom*) The percentage of children with negative emotions ($n = 40$ for Riddle group and $n = 41$ for Storytelling group). ##Significant difference between groups (Pearson's $\chi^2$ test; $P \leq 0.001$).

interaction between narrators and children. The major difference was the presence of narratives for the Storytelling condition. In both groups, the children were delighted by the interventions because they interrupted the otherwise austere routine of the ICU. However, when they learned that they would be listening to stories, the children in the Storytelling group got excited, which might have caused an increase in their cortisol level before the intervention began. In previous studies on stressful life conditions (39, 40), children were found to be very vulnerable to stress (25). Even though stress is not always linked to adverse effects, we know that prolonged exposure to stress hormones during childhood can impact cognition and mental health during adulthood (40). It is well-recognized that hospitalized children may suffer from acute stress and anxiety and that the negative emotions associated with the involuntary confinement, pain, and sense of estrangement they suffer can have a disproportionately large effect on their ability to heal (23–25). These adverse effects can continue after children's hospital stays, provoking separation anxiety, sleep disturbances, depression, and apathy. Unfortunately, some of these negative feelings can persist for months or years, especially among children who experience repeated or lengthy hospital stays (22). For these reasons, the temporary reduction in cortisol levels that children experience after the interventions can be highly beneficial since elevated cortisol levels can negatively affect the immune system and cognition (41, 42).

Finally, it seems that the combination of increased oxytocin and reduced cortisol may reduce the negative emotions associated with hospitalization (36) and influence children's perception of pain: Children in the Storytelling group registered a decline in postintervention pain sensation at a rate twice as large as those in the Riddle group.

One unique feature of our study is that we did not predetermine highly emotional stories or alter the emotional values of the stories used in the experiment. Few studies have directly investigated the effects of storytelling on human physiology (43). We have shown that listening to stories, by the social act of storytelling itself or by conveying meaning, can temporarily raise oxytocin levels. However, it is necessary to reiterate that the stories that we used are widely available in children's reading books and were not chosen with intense emotional content in mind. The objective was simply to evaluate the role of narratives in establishing physiological conditions that would help a child's recovery or at least temporarily alleviate suffering.

From a psychological point of view, other studies have already pointed out the role of words in promoting the development of essentially human cognitive functions (44). We speculate that storytelling combines the structural elements of words, thoughts, and relations together with mental imagery, that is, "representations and the accompanying experience of sensory information without a direct external stimulus" (45) which can help reconfigure the way people—and children in particular—integrate emotions, experience, and meaning toward a purposeful and meaningful view of life during challenging moments.

From a neuroscientific standpoint, there is growing evidence that stories can transport listeners and readers. Kurby and Zacks (46) found that stories with auditory or motor simulations activated the sensory-motor cortex in a congruent way. In the same way, narratives that describe sounds activate the auditory cortex, left superior temporal gyrus, and bilateral superior temporal sulcus in addition to the left posterior superior temporal gyrus at the temporoparietal junction and left inferior frontal gyrus—regions associated with the processing of auditory events and higher-level language and conceptual thinking. Similarly, narratives that focus on motor events such as body movement activate regions in the left premotor and left secondary sensorimotor cortex (47). There is evidence of this same process in listeners' and readers' recognition of the intentions, beliefs, and mental and emotional states of story characters. This immersion within narratives has been shown to engage brain regions such as the dorsomedial and prefrontal cortex, precuneus, superior parietal lobule, and posterior superior temporal sulcus, supporting the view that narratives are associated with making inferences about the mental states of others (17, 48). Other results indicate that narratives activate the default mode network, including the medial prefrontal cortex, posterior cingulate cortex, posterior superior temporal sulcus, temporal parietal junction, anterior medial temporal gyrus, and medial temporal lobes, all of which are involved in the processes of mental simulation and theory of mind (49, 50). We hypothesize that children, albeit momentarily, are transported to another possible world during storytelling sessions. That world, distant from the anxiety-provoking hospital environment and the tedious, if not utterly aversive, ICU setting, can elicit positive physiological and psychological changes. These processes appear of relevance for clinical explorations of visual imagery as therapeutic tools given the overlap of cortical areas engaged by narratives, mental imagery, and emotional content (45).

It is important to note that even though we have used experienced storytellers for our research purposes, we believe that parents should be encouraged to tell their children stories. As we have shown, it is not necessary to use special stories or books or even specific techniques to achieve a successful outcome. Storytelling can be an effective means of creating important emotional bonds. It is also important to highlight that in allowing children to choose a book that was more meaningful or interesting to them we allowed them to exert control and maintain their agency, which can be highly valuable in a frightening and disempowering ICU environment.

Our results illustrate that storytelling and narrative fiction go well beyond simple entertainment value. To date, relatively little scientific research has examined possible psychological mechanisms behind storytelling. There is still much to understand about the role of stories and how story features and structures produce various psychological and physiological effects (50). We focused on one possible mechanism, namely the transportation function of narratives. This unfolding of stories [e.g., the narrative arc (51)] provides a context that allows individuals to identify with the main characters, become emotionally invested, simulate different mental worlds, and allow a temporal dislocation from the here and now—all of which contribute to the development of adaptive psychological and behavioral reactions when dealing with challenging real-life situations.

Listening to stories necessitates that children utilize abstractions that enhance their understanding of their own emotions and the emotions of their caretakers (including nurses and doctors, acquaintances, and relatives). Stories possess a symbolic dimension that seems to create a natural bridge to the core of our humanity. We believe that our results provide insight into how physiological, biological, and cultural variables are closely interlinked. Further, they suggest a promising venue for developing safe, innovative, and cost-effective behavioral interventions (52) to improve psychological health and reduce the suffering of hospitalized children.

## Materials and Methods

We have complied with all relevant ethical regulations, and the study protocol was approved by the responsible Research and Ethics Committee (Instituto D'Or de Pesquisa e Ensino no. 43008114.1.0000.5249). Parents or legal guardians signed children's consent forms.

We conducted a double-blind experiment. Neither the subjects nor the storytellers were aware of the research hypotheses. They were told that we were investigating the impacts of two hospital interventions. Children were randomly assigned to one of the two conditions by a coin toss (A/B group allocation) performed by a researcher outside the hospital. The results from this process were sent to the psychologist who was running the study at the hospital the night prior (using either email or text message). Storytellers were also selected using this method. The selected storyteller was then responsible for administering both the story and the riddle condition.

We recruited 81 children who were hospitalized in ICUs (age 7.20 ± 2.12 y, mean ± SEM), randomized into two intervention groups: 1) Storytelling ($n$ = 41) and 2) Riddle ($n$ = 40). Sample sizes were constrained by medical logistics and the availability of suitable patients within the hospital.

After the psychologist explained the study procedures and obtained signed consent from their parents, we asked the children to choose where they were on a pain scale and to state how they were feeling at the moment.

**Salivary Samples.** After this initial step, saliva samples were collected from each child to evaluate their physiological scores. The samples were collected twice; the first sample was collected 1 min before the intervention, and the second sample was collected immediately after its completion. Saliva was collected using the SalivaBio Oral Swab (exclusively from Salimetrics), a synthetic swab specifically designed to improve volume collection and increase participant compliance and validated for use with saliva. The swab was placed under each child's tongue or between the cheek and dental arch and held in place for a period of 2 to 3 min. The child was also asked to gently chew the cotton to stimulate the salivary flow. During the collection period, participants were not allowed to ingest water, food, or liquid of any kind. After the time elapsed, the psychologist removed the swab from the child's mouth and returned it to the plastic tube, sealing it immediately. The volume of saliva we obtained with this procedure measured between 2.0 and 2.5 mg. All of the interventions took place between 2:00 PM and 5:00 PM to guarantee that the children were wide awake with sufficient time after the last meal (lunch, which was virtually the same for all the study participants, was served at 11:30 AM) and that hormone levels were unaffected by the endogenous fluctuations of cortisol. All samples were immediately stored for preservation in a sterile tube in a freezer set to −80 °C. Samples were brought to room temperature and centrifuged at ∼1,500 × $g$ for 15 min before testing. They were analyzed by a professional company specializing in the research of these biomarkers. We assessed cortisol concentrations using a Salimetrics Cortisol Enzyme Immunoassay following the manufacturer's protocols and design (Salimetrics). We assessed oxytocin concentrations using an Oxytocin ELISA kit following the manufacturer's protocols and design (Enzo Life Sciences). We examined each sample in duplicate and calculated the concentrations using a microplate reader according to relevant standard curves provided by the manufacturers. Following post-intervention saliva collection, every child responded again to the pain scale and completed the free word association in response to the seven cards presented in *SI Appendix*.

**Statistical Analysis.** Student's $t$ test and two-way ANCOVA controlling for age, gender and time of day were used for the statistical analysis. All values were considered significant when $P < 0.05$. Data are presented as the mean and SEM (± SEM). Pearson's $\chi^2$ tests and Cramér's V size effects were used for statistical analysis of contingency tables in the free association experiments. Additional analyses are available in the *SI Appendix* section.

**Post hoc Power Analysis.** We conducted a post hoc power analysis using the GPower software package (53). We focused on the time two difference between the experimental groups, using a two-sided $t$ test. Using the smallest effect size encountered in our study (which was observed for the pain scale), we had a power level of 0.99 to find a statistically significant effect at $P < 0.05$. When examining what level of effect size d we minimally needed with a power of 0.80 to obtain a significant effect, the calculations suggested a d of 0.65. Therefore, our post hoc analyses indicated that the sample size, observed effect sizes, and statistical effects were sufficient to allow for meaningful comparison.

**Data Availability.** Anonymized .xml files containing biomarker values and all data .doc files with childrens' responses to the free-association task have been deposited in Open Science Framework (OSF) and are available online at https://osf.io/bdxg2/.

**ACKNOWLEDGMENTS.** We gratefully acknowledge Dora Estevez, Jefferson Feitosa, Malu Barros, Tânia Maria Mendes da Cruz Moraes, and Vera Carneiro Gracitelli, the best storytellers ever! Without them, the magic could not have happened. We also thank Andrea Coltelli, Isabela Gimenez, and Valdir Cimino from Viva e Deixe Viver, a nonprofit association that has been training volunteers to tell stories that transmit joy and tenderness to hospitalized children since 1997. We thank Mr. Peter Lownds, another wizard of stories, for helping us with the storytelling that is life, and sincerely acknowledge Flávio Ferraz Vieira for his contributions to the new analysis. We thank Dr. Paul Zak for methodological advice during the early stages of this project. We also acknowledge the D'Or Institute for Research and Education for all the financial support.

1. D. Brown, *Human Universals* (McGraw-Hill Humanities, Social Sciences/Languages, 1991).
2. J. S. Bruner, *Making Stories: Law, Literature, Life* (Harvard University Press, 2003).
3. K. Coe, N. E. Aiken, C. T. Palmer, Once upon a time: Ancestors and the evolutionary significance of stories. *Anthropological Forum* **16**, 21–40 (2006).
4. R. I. Dunbar, How conversations around campfires came to be. *Proc. Natl. Acad. Sci. U.S.A.* **111**, 14013–14014 (2014).
5. D. Smith *et al*., Cooperation and the evolution of hunter-gatherer storytelling. *Nat. Commun.* **8**, 1853 (2017).
6. P. W. Wiessner, Embers of society: Firelight talk among the Ju/'hoansi Bushmen. *Proc. Natl. Acad. Sci. U.S.A.* **111**, 14027–14035 (2014).
7. B. Boyd, The evolution of stories: From mimesis to language, from fact to fiction. *Wiley Interdiscip. Rev. Cogn. Sci.* **9**, e1444 (2018).
8. J. Bruner, Life as narrative. *Soc. Res. (New York)* **54**, 11–32 (1987).
9. M. Gazzaniga, R. B. Ivry, *Cognitive Neuroscience: The Biology of the Mind: Fourth International Student Edition* (W. W. Norton, 2013).
10. R. A. Mar, Stories and the promotion of social cognition. *Curr. Dir. Psychol. Sci.* **27**, 257–262 (2018).
11. R. A. Mar, K. Oatley, The function of fiction is the abstraction and simulation of social experience. *Perspect. Psychol. Sci.* **3**, 173–192 (2008).
12. R. A. Mar *et al*., Bookworms versus nerds: Exposure to fiction versus non-fiction, divergent associations with social ability, and the simulation of fictional social worlds. *J. Res. Pers.* **40**, 694–712 (2006).
13. R. J. Gerrig, *Experiencing Narrative Worlds* (Yale University Press, New Haven, CT, 1993).
14. K. Oatley, Fiction: Simulation of social worlds. *Trends Cogn. Sci.* **20**, 618–628 (2016).
15. M. C. Green, T. C. Brock, The role of transportation in the persuasiveness of public narratives. *J. Pers. Soc. Psychol.* **79**, 701–721 (2000).
16. T. Van Laer *et al*., The extended transportation-imagery model: A meta-analysis of the antecedents and consequences of consumers' narrative transportation. *J. Consum. Res.* **40**, 797–817 (2014).
17. D. I. Tamir, A. B. Bricker, D. Dodell-Feder, J. P. Mitchell, Reading fiction and reading minds: The role of simulation in the default network. *Soc. Cogn. Affect. Neurosci.* **11**, 215–224 (2016).
18. P. M. Bal, M. Veltkamp, How does fiction reading influence empathy? An experimental investigation on the role of emotional transportation. *PLoS One* **8**, e55341 (2013).
19. M. Djikic, K. Oatley, M. C. Moldoveanu, Reading other minds: Effects of literature on empathy. *Sci. Study Lit.* **3**, 28–47 (2013).
20. C. Haigh, P. Hardy, Tell me a story–A conceptual exploration of storytelling in healthcare education. *Nurse Educ. Today* **31**, 408–411 (2011).
21. J. De la Torre, The therapist tells a story: A technique in brief psychotherapy. *Bull. Menninger Clin.* **36**, 609–616 (1972).
22. B. M. Melnyk, Intervention studies involving parents of hospitalized young children: An analysis of the past and future recommendations. *J. Pediatr. Nurs.* **15**, 4–13 (2000).
23. E. Bossert, Stress appraisals of hospitalized school-age children. *Child. Health Care* **23**, 33–49 (1994).
24. M. E. Tiedeman, S. Clatworthy, Anxiety responses of 5- to 11-year-old children during and after hospitalization. *J. Pediatr. Nurs.* **5**, 334–343 (1990).
25. H. Schreier, C. Ladakakos, D. Morabito, L. Chapman, M. M. Knudson, Posttraumatic stress symptoms in children after mild to moderate pediatric trauma: A longitudinal examination of symptom prevalence, correlates, and parent-child symptom reporting. *J. Trauma* **58**, 353–363 (2005).
26. E. Charmandari, J. C. Achermann, J. C. Carel, O. Soder, G. P. Chrousos, Stress response and child health. *Sci. Signal.* **5**, mr1 (2012).
27. S. M. Rodrigues, L. R. Saslow, N. Garcia, O. P. John, D. Keltner, Oxytocin receptor genetic variation relates to empathy and stress reactivity in humans. *Proc. Natl. Acad. Sci. U.S.A.* **106**, 21437–21441 (2009).
28. A. Meyer-Lindenberg, G. Domes, P. Kirsch, M. Heinrichs, Oxytocin and vasopressin in the human brain: Social neuropeptides for translational medicine. *Nat. Rev. Neurosci.* **12**, 524–538 (2011).
29. J. Dębiec, Peptides of love and fear: Vasopressin and oxytocin modulate the integration of information in the amygdala. *BioEssays* **27**, 869–873 (2005).
30. P. Petrovic, R. Kalisch, T. Singer, R. J. Dolan, Oxytocin attenuates affective evaluations of conditioned faces and amygdala activity. *J. Neurosci.* **28**, 6607–6615 (2008).
31. G. Russell, S. Lightman, The human stress response. *Nat. Rev. Endocrinol.* **15**, 525–534 (2019).
32. S. Szabo, Y. Tache, A. Somogyi, The legacy of Hans Selye and the origins of stress research: A retrospective 75 years after his landmark brief "letter" to the editor of Nature. *Stress* **15**, 472–478 (2012).
33. J. W. Pennebaker, M. E. Francis, R. J. Booth, *Linguistic Inquiry and Word Count: LIWC* (Lawrence Erlbaum Associates, Mahwah, NJ, 2001).
34. Y. R. Tausczik, J. W. Pennebaker, The psychological meaning of words: LIWC and computerized text analysis methods. *J. Lang. Soc. Psychol.* **29**, 24–54 (2010).
35. P. P. Balage Filho, T. A. S. Pardo, S. M. Aluísio, "An evaluation of the Brazilian Portuguese LIWC dictionary for sentiment analysis" in *Proceedings of the 9th Brazilian Symposium in Information and Human Language Technology* (Association for Computational Linguistics, 2013), pp. 215–219.

36. M. Heinrichs, T. Baumgartner, C. Kirschbaum, U. Ehlert, Social support and oxytocin interact to suppress cortisol and subjective responses to psychosocial stress. *Biol. Psychiatry* **54**, 1389–1398 (2003).
37. T. Baumgartner, M. Heinrichs, A. Vonlanthen, U. Fischbacher, E. Fehr, Oxytocin shapes the neural circuitry of trust and trust adaptation in humans. *Neuron* **58**, 639–650 (2008).
38. D. C. Kidd, E. Castano, Reading literary fiction improves theory of mind. *Science* **342**, 377–380 (2013).
39. N. Fogelman, T. Canli, Early life stress and cortisol: A meta-analysis. *Horm. Behav.* **98**, 63–76 (2018).
40. S. J. Lupien, B. S. McEwen, M. R. Gunnar, C. Heim, Effects of stress throughout the lifespan on the brain, behaviour and cognition. *Nat. Rev. Neurosci.* **10**, 434–445 (2009).
41. N. Schneiderman, G. Ironson, S. D. Siegel, Stress and health: Psychological, behavioral, and biological determinants. *Annu. Rev. Clin. Psychol.* **1**, 607–628 (2005).
42. A. Steptoe, M. Hamer, Y. Chida, The effects of acute psychological stress on circulating inflammatory factors in humans: A review and meta-analysis. *Brain Behav. Immun.* **21**, 901–912 (2007).
43. P. J. Zak, A. A. Stanton, S. Ahmadi, Oxytocin increases generosity in humans. *PLoS One* **2**, e1128 (2007).
44. L. S. Vygotsky, *The Collected Works of LS Vygotsky: Problems of the Theory and History of Psychology* (Springer Science & Business Media, 1997), vol. 3.
45. J. Pearson, T. Naselaris, E. A. Holmes, S. M. Kosslyn, Mental imagery: Functional mechanisms and clinical applications. *Trends Cogn. Sci.* **19**, 590–602 (2015).
46. C. A. Kurby, J. M. Zacks, The activation of modality-specific representations during discourse processing. *Brain Lang.* **126**, 338–349 (2013).
47. A. D. Nijhof, R. M. Willems, Simulating fiction: Individual differences in literature comprehension revealed with FMRI. *PLoS One* **10**, e0116492 (2015).
48. A. M. Jacobs, R. M. Willems, The fictive brain: Neurocognitive correlates of engagement in literature. *Rev. Gen. Psychol.* **22**, 147–160 (2018).
49. Y. Yuan, J. Major-Girardin, S. Brown, Storytelling is intrinsically mentalistic: A functional magnetic resonance imaging study of narrative production across modalities. *J. Cogn. Neurosci.* **30**, 1298–1314 (2018).
50. C. T. Hsu, M. Conrad, A. M. Jacobs, Fiction feelings in Harry Potter: Haemodynamic response in the mid-cingulate cortex correlates with immersive reading experience. *Neuroreport* **25**, 1356–1361 (2014).
51. R. L. Boyd, K. G. Blackburn, J. W. Pennebaker, The narrative arc: Revealing core narrative structures through text analysis. *Sci. Adv.* **6**, eaba2196 (2020).
52. E. A. Holmes *et al*., The Lancet Psychiatry Commission on psychological treatments research in tomorrow's science. *Lancet Psychiatry* **5**, 237–286 (2018).
53. F. Faul, E. Erdfelder, A. G. Lang, A. Buchner, G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav. Res. Methods* **39**, 175–191 (2007).