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RESEARCH ARTICLE



What makes a teddy bear comforting? A participatory study reveals the prevalence of sensory characteristics and emotional bonds in the perception of comforting teddy bears

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ABSTRACT

Considered as a transitional object, the comforting power of the teddy bear has often been asserted in many past studies without knowing its underlying determinants. Through a participatory study conducted during the European Researchers' Night, this study aims to identify characteristics of teddy bears that influence their comforting power, including visual, olfactory and kinesthetic properties. We also tested the effect of ownership on comforting power. Our study revealed that the emotional bond shared with a teddy bear is a predominant factor. However, we identified characteristics that play a significant role in the perception of comfort, which lies in a combination of visual, olfactory, and especially kinesthetic characteristics. Through these results, our study identifies the determinants spontaneously taken into account in the attribution of teddy bears' capacity to provide comfort. These results were independent of participants' age, reminiscent of the teddy bear's ability to provide comfort at all stages of life.

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Introduction

Unlocking the mystery of the power of the teddy bear and more broadly stuffed animals is the main purpose of this article. What are the determinants spontaneously taken into account in the attribution of this capacity to provide comfort? Are they primarily physical determinants and if so, what are the physical traits of comfort? Is the property of the teddy bear alone a predominant factor? These are the questions that our study attempted to answer to provide a snapshot of the most comforting bear.

Before screening the psychological benefits attributed to teddy bears, it seems useful to start with an historical point on one of the world's most favorite stuffed toy story. In one paper, He (2014) attempted to explain teddy bear's existence and popularity, based on anthropological, philosophical and psychological theories. He (2014; see also, Caldas-Coulthard & van Leeuwen, 2003) reminds us that the teddy bear fever has lasted for more than a century since it relies on one popular cartoon entitled 'Drawing the line in Mississippi'. In this cartoon, printed in the Washington Post in 1902,

US President Roosevelt (nicknamed Teddy) refused to shoot a captive baby black bear that his hosts offered him to fire (see *Drawing the line in Mississippi*. Theodore Roosevelt Papers. Library of Congress Manuscript Division: <https://www.theodorooseveltcenter.org/Research/Digital-Library/Record?libID=o274688>).

Following this story, a stuffed bear was handmade and immediately sold out, giving rise to the production of Teddy's bears in the US (He, 2014). In the same period, the Steiff company in Germany designed a teddy bear, which sold nearly a million copies in 1904 (Vale & Vale, 2016). Nowadays, teddy bears are everywhere, not only as children's favorite toys, but also as a main character in books, films, and cartoons. According to Caldas-Coulthard and van Leeuwen (2003), teddy bears 'play an immensely important role in contemporary life' (p. 26), since they share children's personal feelings and experiences, and can be used as a medium to investigate self-identity and family relationships from memories collected in adulthood.

Unexpectedly, there are serious reasons to consider the teddy bear as a promising research topic.

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Understanding the determinants of the comfort provided by a teddy bear enables us to better understand the psychological functioning of the individuals: in childhood, at the time of separation from parents, the teddy bear is usually invested as a transitional object (see, Winnicott, 1953), namely to help them through this transition. According to Bowlby (1969/1982), children's favored object could be seen as a substitute for their 'natural' attachment figure. When children choose their transitional object, this behavior means that they reach a crucial developmental step: they are able to turn to this object to find comfort and security when their parent or caregiver isn't around. In other words, children are supposed to manage the stress of separation from the mother/caregiver by using their attachment objects. Two studies provided converging evidence for that developmental phenomenon (see, Fortuna et al., 2014; Triebenbacher & Tegano, 1993). Thus, transitional objects are crucial to help children move towards independence through both cognitive and emotional mechanisms: regarding the cognitive side, the teddy bear represents a connection between the parent/caregiver and the external world (or a substitute). Regarding the emotional side, children know that these objects can offer a lot of reassurance to overcome separation anxiety. Fortuna et al. (2014) went one step beyond in the explanation of the occurrence of this behavior: they provided evidence that it could be a coping strategy observed at the age of three. Indeed, they reported that children who spent several hours in center-based child care were more likely to develop attachments to inanimate objects compared to those who spent only half-days in daycare. In adulthood, these so-called transitional objects, which one might think have lost their comforting power, are still present in the daily lives of certain adults who confess to still sleeping with their teddy bear. Indeed, according to a survey conducted in 2017, among the 2,000 American adult respondents, more than half of all respondents surveyed still had their favorite stuffed animal from childhood and 40% of them reported sleeping with their stuffed animal by their side (press release of the market research survey: <https://ir.buildabear.com/news-releases/news-release-details/national-teddy-bear-day-survey-finds-more-half-adult-americans/>). This survey makes salient that this phenomenon does not disappear in adulthood, and could be used to collect reminiscences by adults about their childhood teddy bears. These real-life stories prompted to elicit memories are useful to provide additional evidence on how extraordinarily deep the attachment to teddy bears can be during childhood (see for example, Caldas-Coulthard & van Leeuwen, 2003).

There is other evidence that supports the comforting power of a teddy bear. Indeed, teddy bears are used to create interventions focused on emotional management. Recently, UNICEF Australia and partner Royal Far West has developed a teddy bear intervention to help children recover from trauma after the black summer bushfires that occurred at the end of 2019 and beginning of 2020 (see <https://www.unicef.org.au/blog/unicef-in-action/bushfires-children-recovery>). This intervention was designed to help children cope with this natural disaster. In that case, a teddy bear is used to help children communicate their thoughts and feelings. Another threatening situation was exploited to highlight the efficiency of using a teddy bear to reduce children's negative emotion, namely the context of hospitalization. Bloch and Toker (2008) elaborated an intervention in the form of a 'Teddy Bear Hospital': Children were invited to attend a simulated hospital where they acted like the parents of their own teddy bears. Children were encouraged to take part in their teddy bear's medical examination. Based on this simple procedure, the authors reported that children's anxiety about hospitalization was reduced. Similar results have been reported in a recent study (Morel et al., 2020) where children were invited to simulate the experience of an MRI scanner with a teddy bear in their arms to prepare themselves for the real MRI scanner examination. It appeared that this intervention significantly reduces the anxiety level of the children before undergoing an MRI examination. Moore et al. (2022) provided additional evidences in favor of using 'Teddy Bear Hospital' intervention to study the development of the communication skills in medical students. In all these studies, teddy bears are used to distract children from stressful situations, to reassure them about an unknown medical situation, and to create a special communication link useful to reduce fears and ease the care of young patients.

Overall, the comfort value of teddy bears is often targeted to provide children the opportunity to develop cognitive and emotional skills that contribute to their wellbeing. Finding comfort in touching a teddy bear has also been demonstrated in adults in another context, namely social exclusion (see, Tai et al., 2011). In two experiments, their findings suggest that touching a teddy bear can mitigate the negative effects of social exclusion to increase prosocial behavior. In one study (i.e., study 2), they reported that the relationship between touch and prosocial behavior relies on positive emotion felt. These results invite us to draw perspective on how teddy bears can be used in childhood to attenuate the unpleasant effects of social exclusion.

This study by Tai et al. (2011) particularly points out that emotional regulation is based on underlying

mechanisms that are linked to the sensorial capacity of any individual: touching, looking, smelling, are senses that most individuals are able to mobilize to deduce an emotional feeling. The embodiment theory of emotion is now well known to account for the strong connection between the embodied experiences and their consequences on emotional state (e.g., Barrett & Lindquist, 2008). Regarding the results of this study (Tai et al., 2011), the feeling of exclusion decreases because the act of touching a teddy bear induces a positive emotion and this emotion reduces the feeling of exclusion. According to the embodied theory of emotion, it is not risky to put forward the idea that the characteristics underlying the comfort provided by the teddy bear - which are the subject of our study- are based on this multisensorial interactive experience, knowing that the mechanisms of emotional induction can be based on touch (e.g., Haynes et al., 2022), vision (e.g., Siedlecka & Denson, 2019), or even smell (e.g., Kadohisa, 2013). Similarly, regarding studies reported above in medical or trauma contexts with children, the embodiment theory of emotion is a fruitful conception to understand its beneficial effect on children wellbeing.

All of the aforementioned studies show that teddy bears play an important role in managing emotions, by establishing a particular communication relationship that aims to distract and reassure when struggling with difficult emotions. In other words, when we feel vulnerable, anxious or insecure, teddy bears act as an attachment figure to restore our sense of attachment security (Bell & Spikins, 2018). Also, while the embodiment theory of emotion (e.g., Barrett & Lindquist, 2008) provides a relevant context to approach this phenomenon, very few studies have focused on the physical and sensory characteristics of these teddy bears, and how these attributes influenced their comforting power. A first line of response lies in the evolutionary history of the teddy bear.

At the beginning of the 20th c. early teddy bears represented the wild animal realistically: they had long arms, elongated muzzle, and a humped back (Caldas-Coulthard & van Leeuwen, 2003). As an object meant to arouse attraction, affection and attachment, the shape of the teddy bear has naturally evolved to adopt infantile characteristics corresponding to the 'baby schema'. Originally proposed by Lorenz in 1943 then in 1970 and followed by Gould in 1979, this concept postulates that juvenile facial features (i.e., large head, round face, large forehead, large eyes, Glockner et al., 2009) are perceived as cuteness and trigger caretaking behavior by affecting attentional processes. Several empirical studies have confirmed Lorenz's hypotheses, including for instance, the effect of babies' facial features on mother-

child interaction: mothers of cute babies showed more affectionate behavior than mothers with less cute babies (Langlois et al., 1995). More recently, the universality of the perception of cuteness has been investigated, showing that animals were also perceived as cute when they exhibited juvenile facial characteristics (Golle et al., 2013; Little & Fusani, 2012), and triggered careful behavior (Nittono et al., 2012). Borgi et al. (2014) showed that response to juvenile facial features of both humans and animals also affects cuteness perception in children, therefore appearing early during development. This statement comes in line with the positive effects of cute animals on children's emotional development (Endenburg & van Lith, 2011). It is therefore not surprising that transitional objects (such as teddy bears), intended to create emotional bonds, also exhibit cuteness through juvenile facial features. The teddy bears faces have thus logically 'evolved' and deviated from the early bears to adopt more attractive characteristics, following a selection guided by teddy bear owners' preferences. Beyond the facial features, the teddy bear also has much softer fur than its natural counterparts, and a design that allows it to be manipulated like a toy or a doll, enhancing its interactive properties (Caldas-Coulthard & van Leeuwen, 2003). If these few characteristics are shared by all, there is however today a wide variety of shapes, colors, and textures within teddy bears.

The objective of this study was to identify whether particular physical and sensory characteristics contribute to making a bear more comforting. The outcomes would be of great interest to psychologists and pediatricians who use teddy bears for therapeutic purposes, since it would ease to identify the best candidates to accompany children when they must overcome difficult emotions. One of our hypotheses is that teddy bears with smiling faces could be perceived as more comforting. Humans are indeed able to attribute mental states to living and non-living objects via anthropomorphism, based on their behaviors or expressive qualities (Urquiza-Haas & Kotrschal, 2015). It is therefore expected that attribution of positive and reassuring emotional states will be favored by smiling teddy bears. Finally, if physical and sensory characteristics play an important role in comforting power, we acknowledge that a main factor that arouses affection for a teddy bear lies in the emotional experience shared with it (He, 2014). The specific bond between people and their teddy bears probably plays a much bigger role than physical and sensory characteristics. We thus have to keep in mind that affective dimension could bias the link between comforting power and physical and sensory characteristics.

The present study aims to (i) identify and quantify physical and sensory characteristics (visual, olfactory and kinesthetic) of teddy bears that influence their comforting power and more generally that sustain this embodied emotional interactive experience; (ii) test, among the visual determinants, the effect of facial expression (in particular the smile) and facial features (in particular infantile features relating to the 'Baby Schema'); and (iii) testing the effect of ownership, through emotional bonds, on comforting power.

Material and Methods

Participants

The participants consisted of people who took part in a participatory study conducted on a national scale during the European Researchers' Night. Funded under the Marie Skłodowska-Curie Actions, this Europe-wide yearly event allows researchers to organize educational and entertainment activities highlighting the diversity of science and its impact on citizens' daily lives. A total of 930 participants contributed to the participatory study, but a part of the contributions has been removed from the dataset for analysis (see 'data sorting' for more details). Among the 395 remaining participants, 60% were female, the mean age was 18 years, the median age was 12 years, 75% of participants were under 27 years, and 75% of participants had between 0 and 2 siblings (Figure 1). The participatory study took place on 27 September 2019, in 13 French cities simultaneously (i.e., Toulouse, Albi, Marseille, Bordeaux, Limoges, St-Etienne, Angers, Le Mans, Brest, Dijon, Besançon, Paris, St-Denis de la Réunion). In each city the event was supervised by local scientific

collaborators (see Acknowledgements). The event was open to children and adults, regardless of age. Children under 10 years of age were usually accompanied by an adult to perform the activities.

Material

Provided tools

Questionnaires were supplied as paper form (see *Supplemental online material*) or on a dedicated website (<https://nounours.umontpellier.fr/>). The online form could be completed by each participant who created an account, using their smartphone or a tablet loaned by the organizers. All the tools necessary for morphometric measurements were provided to the participants: tape measures, rulers, scales and pens. Facilitators were present to support participants during the activities.

Standard bears

The use of standard bears was intended to provide standardized benchmarks in each city during matches, enabling the indirect comparison of comfort scores of every bear from all the cities. Eight standard bears were chosen in such a way as to represent a maximum of physical diversity, while minimizing costs and respecting certain constraints (e.g., there were no very large bears because they had to be sent by parcel in each city). The standard bears therefore filled an acceptable spectrum of physical characteristics to be used as elements for inter-city comparisons. An illustration of the principal component analysis of the standard bears' distribution of according to their morphometric attributes is shown in Figure 2b. Axis 1 (56% of explained variance), was mostly explained by muzzle volume (11.5%), truffle circumference (11.2%) and length of front legs (9.5%). Axis

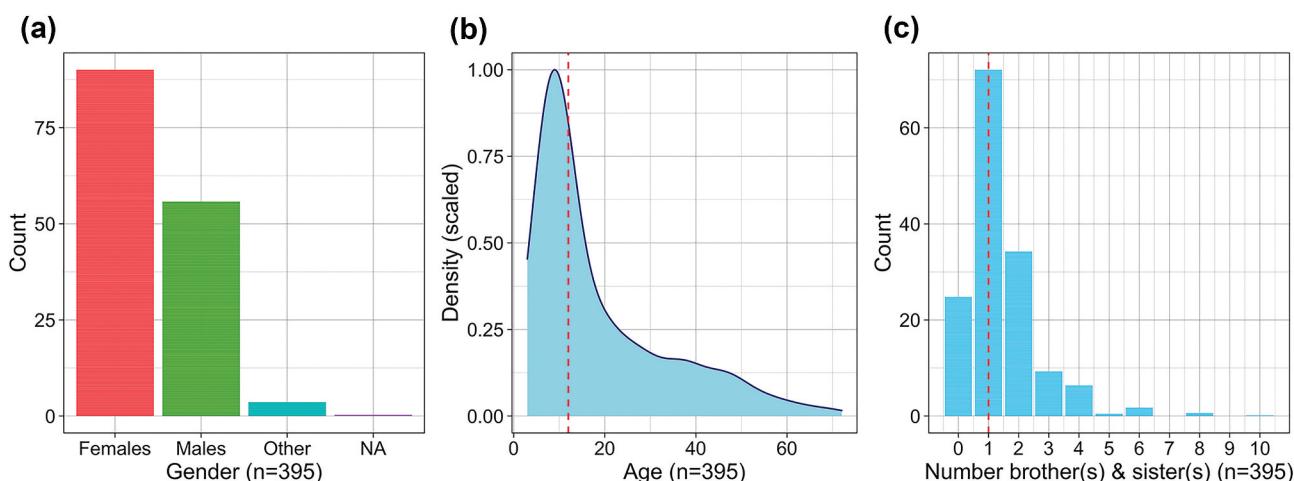
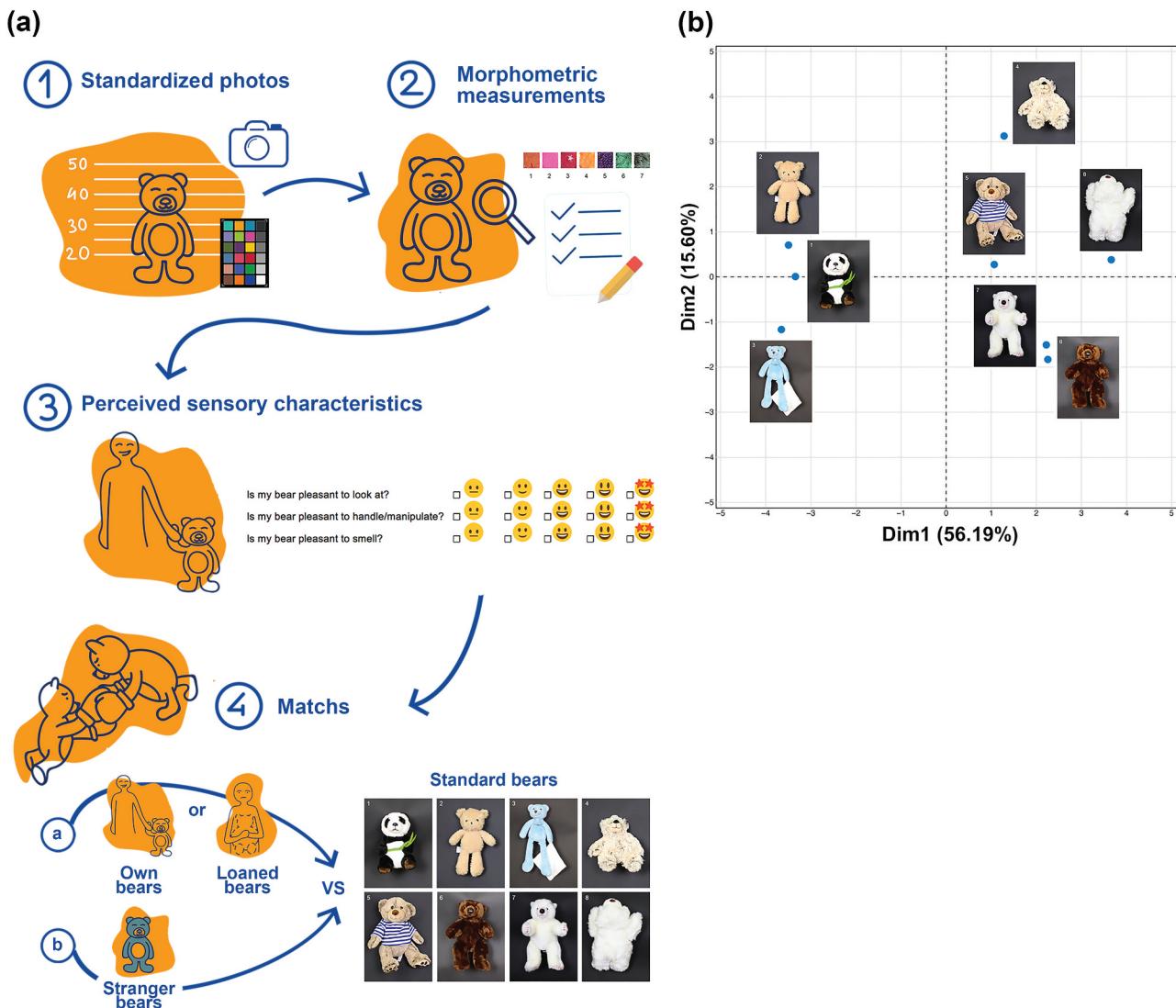


Figure 1. (a) Counting of participants by gender. (b) Density curve of the distribution of participants according to their age. (c) Counting of number of siblings per participants. Dotted red lines = median.



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Figure 2. (a) Graphical abstract of the participatory study. Illustrations: John Bandelier (Kimiyo). (b) Principal component analysis of the distribution of standard bears according to their continuous variables (morphometric measurements and interaction variables).

2 (15.6% of explained variance) was mostly explained by the relative diameter of the eyes (24.4%), length of the fur (17.8%) and length of hind legs (17.8%).

Photo studio

In order to guarantee the standardization and the traceability of the photographs, the photo studio was composed of a plain background on which the bears were attached (using string, clips or velcro), a sign containing their name chosen by the participant, and a colorimetric test chart (a cardboard-framed arrangement of twenty-four squares of painted samples). This one is intended to calibrate *a posteriori* the colorimetry of the photos: the

colorimetry (CIE-L*a*b* values) of each square of the test chart was measured using a spectrophotometer and converted into RGB values. These values were then used as colorimetric standard to recalibrate the photographs, using an adapted version of the R shiny app developed by Steven M. Van Belleghem (https://stevenvanbelleghem.shinyapps.io/shiny_colorchecker/).

Procedure

In order to collect both a large amount of measurable data on teddy bears appearance, and to test their comfort potential by a large panel of participants, the event

consisted of four steps: (i) standardized photographs of the teddy bear, (ii) morphometric measurements, (iii) questionnaire related to perceived sensory characteristics, (iv) measurement of comfort score using a set of matches (Figure 2a). The data were reported by the participants either on a paper form (see *Supplemental online material*) or on a dedicated website (<https://nouhours.umontpellier.fr/>). During the reception of participants, a consent form was signed for each of them (or their legal representative), in accordance with the regulations provided by the CNIL (National Commission for Information Technology and Civil Liberties of France). To participate in the event, each participant could either bring their own teddy bear (later called *own bears*) or use a teddy bear loaned by the organizers (later called *loaned bears*).

(i) Standardized photographs

A photo studio was set up in each city for participants to photograph the teddy bears (see *Material* for details). Each participant placed the bear in the photo studio and took a picture of it, using their own camera or material loaned by the organizers.

(ii) Morphometric measurements

Using a form (online or paper questionnaire, see *Supplemental online material*) and provided tools, participants measured three types of variables: (i) visual characteristics (nominal variables): dominant color, posture, presence of accessories and presence of a smile; (ii) metric measurements (continuous variables): body length and width (converted *a posteriori* in body volume), head length and width (converted in head volume), muzzle length and width (converted in muzzle volume), truffle diameter (converted in circumference), eyes diameter, length of front and hind legs, ears length; and (iii) kinesthetic properties (continuous variables): length and softness of the fur. For these last categories, we used a ruler composed of seven textile patches (Figure 2a), classified according to their length and softness. The participant was asked to choose by touch the patch that was closest to the teddy bear's fur. As length and softness are correlated (Singh et al. 2014), and to ensure the simplicity of the protocol, we used a single ruler to measure these two variables. Note that softness and pleasantness to touch were *a posteriori* grouped in a single variable by adding the two.

(iii) Declarative variables

The perceived sensory characteristics of the teddy bears were measured by 5-point rating scales composed of the following items: 'Is my bear pleasant to look at?'; 'Is my bear pleasant to handle/manipulate?'; 'Is my bear

pleasant to smell?'. In order to make the questionnaire more accessible to children, the answers to each item were displayed as emojis (see, Figure 2a and *Supplemental online material*). As mentioned above, pleasantness to touch was *a posteriori* grouped with softness of the fur for further analyses.

(iv) Measurement of comfort score using a set of matches

This activity consisted of two parts: (i) evaluation of the participant's own bear (called *own bears*) or one loaned by the organizers (called *loaned bears*); (ii) evaluation of another participant's bear (called *stranger bears*). For these two evaluations, the bear (own, loaned or stranger) was sequentially confronted with the 8 standard bears (Figure 1, see *Material* for details) randomly placed on a table. These standard bears were common to all cities, enabling for comparable matches on a national scale: each time, we asked the participants to choose 'which of these two bears would you rather cuddle if you were sad or scared?'. Each choice made by the participant was considered a 'match'. The comfort score for each bear was then calculated based on the mean number of matches won (1) and lost (0).

Results

Data sorting

In order to proceed with the analyses, the stuffed animals that were not teddy bears and unusable photographs (blurred or not well framed) were removed. The outliers were identified by hand and removed. The absence of outliers was verified *a posteriori* by using a Grubbs' test. Inconsistent data in metric measurements were manually corrected using ImageJ software (<https://imagej.nih.gov/ij/>) based on the photographs and using the test charts as a standardized metric scale. The final dataset consisted of 395 identified bears (190 own and 205 loaned), against 930 before the data sorting. Finally, the metric measurements (continuous variables) were log transformed and standardized.

Comfort score

The comfort score was calculated separately for own, loaned and stranger bears. The comfort score of a bear was calculated as the proportion of matches won against the standard bears. As the difference in comfort scores between loaned bears and stranger bears was not significant (Wilcoxon test p-value = 0.443), we further used the mean comfort score of these two groups to characterize all the stranger bears (n = 281). This last

category therefore represents the bears with which the participants have not developed a particular emotional bond.

The effects of age, gender and number of siblings of participants on the comfort scores were tested using Kruskall-Wallis tests. For all these variables, tests were not significant (all p -value > 0.05). We thus kept all participants in a single group for the analyses. We tested for significant differences in mean comfort scores according to cities using Kruskal-Wallis then pairwise-comparison Wilcoxon tests. These tests showed significant differences only between Besançon and St-Etienne (Wilcoxon test p -value = 0.035), showing an acceptable general homogeneity between cities. Note that the difference between Besançon and St-Etienne could be related to a sampling effect due to the low number of participants ($n = 15$) in St-Etienne. After removing the city of St-Etienne and carrying out a new Kruskall-Wallis test, the differences between the mean scores for each city were not significant (p -value > 0.05). We thus have chosen to remove the contributions of St-Etienne from the dataset for further analysis.

For these and subsequent analyses, we opted for non-parametric tests because the distributions of the intragroup variables did not allow for a normal distribution of parametric test residuals (p -values of Shapiro tests all < 0.01).

Effect of physical and sensory characteristics on comfort score

Visual characteristics (nominal variables)

Effects of each visual characteristic (dominant color, posture, presence of accessories) on comfort score were separately tested using Wilcoxon tests for variables with two modality, and Kruskal-Wallis tests for more than two modalities. No visual characteristics had significant effects on the comfort score of own bears or stranger bears (Wilcoxon and Kruskal-Wallis tests, all p -value > 0.05).

Morphometric measurements and declarative variables (continuous variables)

In order to analyze and prioritize the effect of each continuous variable on the comfort scores, we computed a general linear regression model for stranger and own bears. Continuous variables included both morphometric measures and interaction variables (body volume, head volume, muzzle volume, truffle circumference, eyes diameter, length of front and hind legs, ears length, length of the fur, softness, pleasantness to look at, manipulate and smell). First, we performed a set of multiple correlation using Pearson's correlation coefficient between each pair of variables, and when a coefficient was higher than 0.7, we removed the variable that was less correlated with the

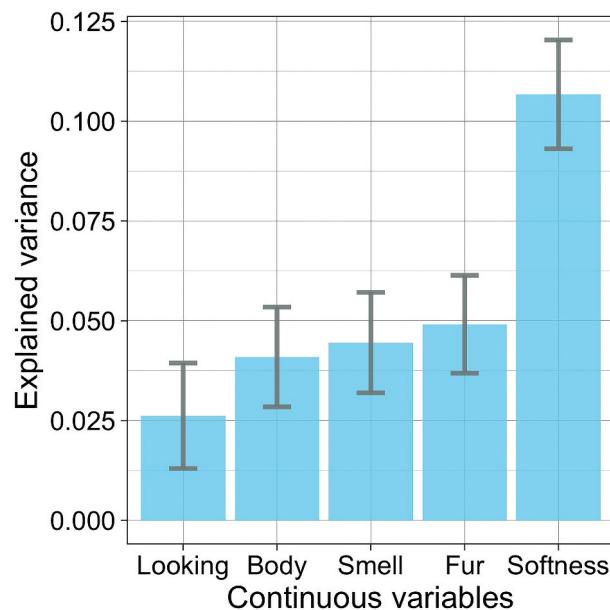


Figure 3. Explained variances of continuous variables with significant effect on stranger bears comfort score. 'Looking' = Pleasantness to look at; 'Body' = Body volume; 'Smell' = Pleasantness to smell; 'Fur' = Length of the fur; 'Softness' = Variable grouping softness of the fur and pleasantness to touch.

comfort score. We then calculated a first linear model with the remaining variables, reordered according to their percentage of explained variance. Non-significant variables (p -values > 0.05) were then sequentially removed to build a final model, for which remaining variables were scaled. We finally prioritized the effect of the final variables on comfort score by comparing their respective explained variances.

The final regression model with stranger bears ($n = 266$) was highly significant ($p < 0.001$) with a $R^2 = 0.462$. Continuous variables with a significant effect on the comfort score of stranger bears according to the linear regression model are shown in Figure 3 (pleasantness to look at, body volume, pleasantness to smell, length of the fur and softness). Among these variables, softness had the strongest explained variance (10.67%), suggesting a stronger effect of kinesthetic variables. Conversely, the model fitted using own bears ($n = 181$) was not significant (p -value > 0.05) suggesting that the physical and sensory characteristics had no effect on comfort score for participants judging their own bears.

Effect of facial expression and juvenile facial features on comfort score

The objective of this section is to test the hypothesis that the presence of a smile and juvenile traits have a significant effect on the comfort score.

Juvenile traits have been recognized as attractive to humans (i.e., considered as cute, and trigger attention and caregiving) according to the baby schema theory. These traits are commonly found both in human and animal infants (a large head and a round face, a high and protruding forehead, large eyes, and a small nose and mouth). Following Borgi et al. (2014), we summarized juvenile traits in two variables: large eyes (the ratio of the diameter of the eyes to the width of the head), and small nose (the ratio of the length of the muzzle to the length of the head).

Presence of a smile was weakly correlated with comfort score of stranger bears (Wilcoxon test: p-value = 0.027, effect size $r = 0.140$); and not correlated to comfort score of own bears ($p\text{-value} > 0.05$).

Regarding juvenile facial traits, large eyes (the ratio of the diameter of the eyes to the width of the head) was negatively correlated to comfort score of stranger bears (Pearson's correlation test: $p\text{-value} < 0.01$, correlation coefficient = -0.165), and not correlated to comfort score of own bears ($p\text{-value} > 0.05$). Conversely, small noses (the ratio of the length of the muzzle to the length of the head) was positively correlated to the comfort score of the stranger bears (Pearson's correlation test: $p\text{-value} < 0.001$, correlation coefficient = 0.248). The linear models showing the significant relationships between juvenile traits and comfort scores of stranger bears are shown in Figure 4.

Effect of ownership and emotional bonds on comfort score

To test the hypothesis that participants rated their own bear as more comforting compared to stranger bears,

we performed pairwise-comparison Wilcoxon tests with a significance level of 5%, in order to highlight significant differences between the means of the comfort scores. The density curves of distribution of comfort scores for stranger bears and own bears are shown in Figure 5. The density curve for own bears is shifted to the right, showing that these bears had generally higher comfort scores. This result is confirmed by Figure 6: bears brought in and judged by their owners (own bears) had a significantly higher comfort score compared to stranger bears (Wilcoxon test $p\text{-value} < 0.001$).

Analyze of stranger teddy bears' comforting physical and sensory determinants

We computed a supplementary analysis of physical and sensory characteristics using only stranger bears in order to overcome the previously observed ownership effect (Figures 5 and 6) and precisely identify features that had the greatest impact on comfort scores. We used principal component analysis (PCA) to analyze more precisely the continuous variables that had the greatest effect on the distribution of comfort scores of stranger bears, including both morphometric measures and declarative variables (body volume, head volume, muzzle volume, truffle circumference, eyes diameter, length of front and hind legs, ears length, length of the fur, softness, pleasantness to look at, manipulate and smell).

The variables with the strongest effect were identified by their contribution (in %) to the inertia of the selected axes.

Analyses of the distribution of stranger bears' traits on using PCA revealed that body volume, softness and

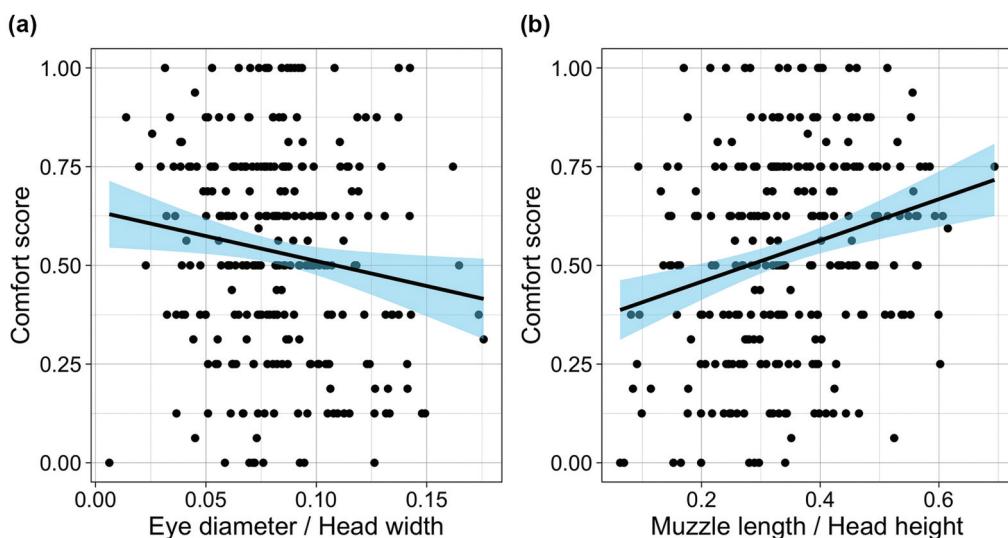


Figure 4. Linear models fitting juvenile traits according to comfort score for stranger bears. (a) Comfort score according to 'large eyes' characteristic (Eyes diameter divided per Head width). P-value = 1.723×10^{-2} , adjusted R-squared = 0.023. (b) Comfort score according to 'small nose' characteristic (Muzzle length divided per Head height). P-value = 4.313×10^{-5} , Adjusted R-squared = 0.058.

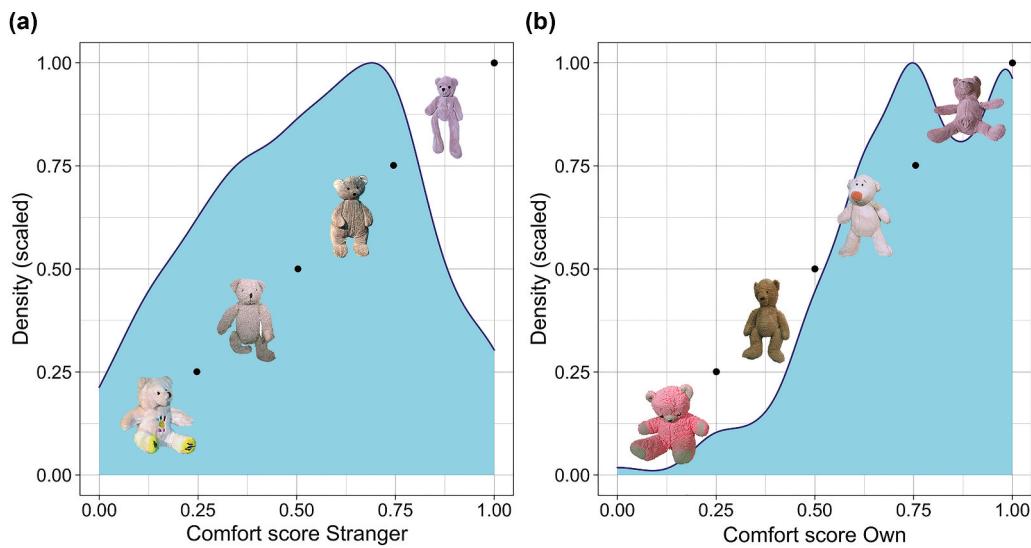


Figure 5. Density curves of comfort scores distributions. (a) Distribution of comfort scores of stranger bears. (b) Distribution of comfort scores of own bears.

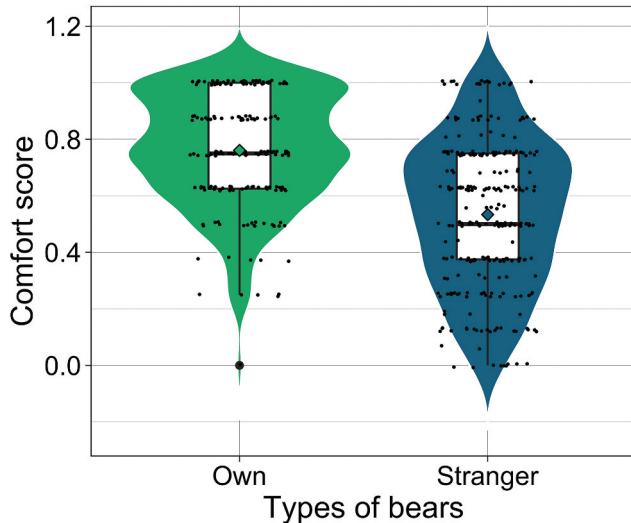


Figure 6. Violin plots of the comfort scores of own bears and stranger bears: colored patches = probability density curve; colored diamonds = mean; black horizontal lines = median; black rectangles = 1st and 3rd quartiles; black vertical lines = 25% lower and higher values.

pleasantness to manipulate had the highest effect on data distribution (Figure 7a, Dim1 = 42.74% and Dim2 = 13.88% of explained variance). Regarding Axis 1 of the PCA, variables that explained the most variance were the muzzle volume, the body volume, and the head volume (respectively, 14.01%, 13.04%, 12.99%). Since these variables are correlated (Pearson's test correlation coefficients: 0.85 for body and head; 0.67 for body and muzzle; 0.68 for head and muzzle), this trend seems to reflect a general positive effect of large bears. Axis 2 was mostly explained by pleasantness to manipulate and

softness (respectively = 25.02%, 24.45%), suggesting a more pronounced effect of kinesthetic variables. To a lesser extent, Axis 2 was also explained by pleasantness to smell (13.25%) and to look (15.14%).

The individual factor map of the PCA (Figure 7b), shows that the bears with the highest comfort scores are located at the top right of the graph. This area corresponds to the declarative variables (softness, pleasantness to manipulate, look and smell) of the variables factor map (Figure 7a). This suggests that perceived sensory characteristics, and particularly kinesthetic, have the most important effect on comfort score.

Discussion

The comforting power of the teddy bear has often been asserted in many past studies and psychological theories without knowing its underlying determinants. This work thus aims to reveal, through a participatory study conducted simultaneously in several French cities during the European Researchers' Night, what are the main characteristics that determine the comforting power of teddy bears. The protocol displayed similarly in all the cities was conceived to examine with a spread sample the teddy bear's comforting power and to answer the following questions: how do the physical and sensory characteristics of the teddy bears contribute to this comforting power? Does ownership, through emotional bonds, play a critical role in attributing this comforting power? Because the teddy bears were manipulated by the participants, this study also captures the weight of different senses in attributing this comforting power, not just based on a visual assessment. If the participatory

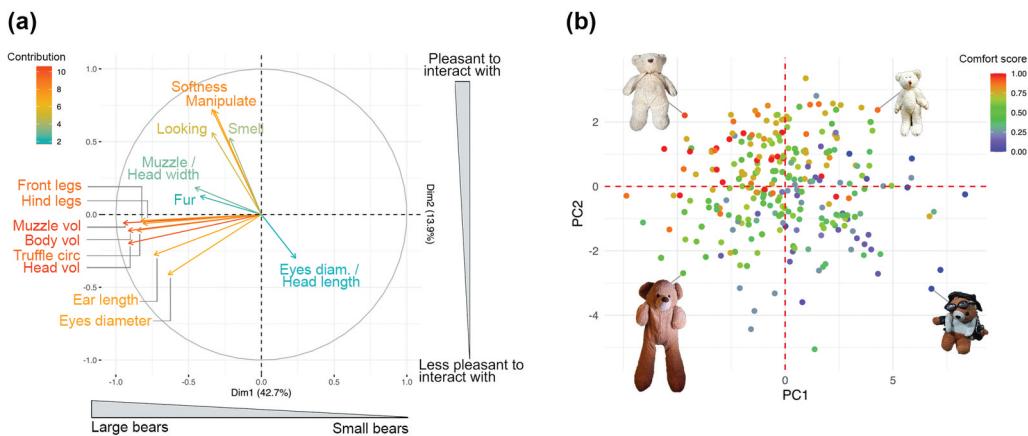


Figure 7. (a) Principal Component Analysis (PCA) of the continuous variables of the stranger bears. (b) PCA's individuals map of stranger bears colored according to comfort score.

context is not as rigorous as that one of laboratory experiments, it made it possible to collect the opinion of many children and adults at the same time in different places in France, avoiding most of the artificial expectation in lab data collection. In addition, participatory sciences practice (such as the European Researchers' Night) has a societal interest since it enhances both public knowledge and understanding of science, and public engagement to science research, practice and policy (Haywood & Besley, 2014).

Ownership and emotional bonds

One of the most important contributions of this study concerns ownership influence related to emotional bonds: The comforting power of the teddy bear is indeed sensitive to this special link. As already underlined by He (2014), the emotional bond built with the teddy bear makes it becomes unique and incomparable. 'Is a good teddy bear worthy of being kept, tendered and loved? The answer does not depend on the function, the degree of depreciation, the fashion trends, or the price, but on the biography of the teddy bear and the emotional experience of the owner with it.' (He, 2014, p. 89). This result has to be linked to other studies reporting that the teddy bear is often used as a mediator to collect personal memories (see, Caldas-Coulthard & van Leeuwen, 2003). It is obvious that more than the ownership, this effect relies on the real-life events shared with the teddy bear, experiencing through personal events its comforting power. This result is also consistent with the attachment theories (see, Winnicott, 1953; see also Bowlby, 1969/1982) since it gives support to the idea that the emotional bonds outweigh the importance of the teddy bear's physical and sensory characteristics providing comfort. In one sense, this participatory study

provides indirect additional evidence regarding this well-known psychological phenomenon which corresponds to a general tendency in individuals to attribute a comforting power to a transitional object aiming to enable them to overcome difficult emotional moments (e.g., Bell & Spikins, 2018). This is also consistent with the survey conducted in 2017 which highlights that this phenomenon persists even in adulthood, the teddy bear remaining invested with this comforting power acquired throughout childhood (see the press release of the market research survey: <https://ir.buildabear.com/news-releases/news-release-details/national-teddy-bear-day-survey-finds-more-half-adult-americans/>).

Beyond the ownership and emotional bonds, we were able to identify a few characteristics that play a significant role in the perception of comfort. If none of them came into play when participants judged their own bears, these characteristics intervene when evaluating 'stranger' bears. These characteristics pertain to the perceptive dimensions which generally underlying the comforting power attributed to most of the teddy bears. To determine what are the properties the most comforting teddy bear should possess, when no affective, emotional bond has been established through personal history shared, the scoring of stranger bears is particularly informative.

Visual characteristics

The fact that a bear was pleasant to look at (according to participants' statements) was a characteristic that played a statistically significant role in comfort. As recently reported by Cheung et al. (2019), commercial stimuli can elicit positive emotions when they are considered as beautiful. Although no teddy bear was used in their study, it seems relevant to make a parallel with our study

where aesthetic design of this artifact may contribute to its comforting power. If the reasons why a teddy bear is pleasant to watch remain unclear, our study still demonstrates the influence of the visual dimension during an interaction with a teddy bear. Among all the measured visual characteristics, body volume had the greatest effect on comfort. In other words, big bears are perceived as more comforting. In fact, this preference for larger bears may not be related to the visual dimension of attractiveness, but may rather be related to kinesthetic characteristics (larger bears being easier to handle and cuddle), this point is discussed further. Other visual characteristics, such as color, posture or accessories showed no link with the comforting value.

Juvenile facial features

Surprisingly, juvenile facial traits were not correlated to the comforting value of the teddy bears, while features that align with the baby schema were expected to be rated as more comforting (Glocker et al., 2009). The lack of variability of facial traits in the sampled teddy bears could be a plausible explanation for these results. In other words, it seems that the sampled teddy bears all exhibit traits outlined as juveniles, all being fairly recent. A possible way of improvement could be the addition in the study of older teddy bears (from the beginning of the 20th century) in order to increase the variability in facial features. However, such teddy bears are collector's items, and therefore difficult to acquire.

Facial expression

Contrary to the initial hypothesis, presence of a smile did not appear as a determinant factor of comfort. A possible explanation for this result is that while respondents found bears that are pleasant to look at more comforting, the presence of a smile alone does not explain this preference. In this case, the effect of expressive qualities would then have been measured by the variable 'the teddy bear is pleasant to look at' rather than by the presence or absence of a smile. Another way of explanation could be that the sampled teddy bears generally had positive facial expressions, regardless of whether they had a smile or not. Additionally, in some particular cases, the smile could have been interpreted as frightening or disturbing rather than comforting. To overcome this limitation, it would be required to equally sample teddy bears exhibiting different facial expressions, *a priori* identified as clearly negative, positive or neutral. At least, our results deserve to be linked to the studies showing evidence for the strong ability to detect happy emotional facial expression in children and adults (Zsido et al., 2021). Although this effect has been reported on the faces of

peers and non-peers, it seems that teddy bears' happy faces are processed as a whole, not only as a function of the smile it exhibits, the smile itself being a component to study apart in individuals' faces (see for instance, Song et al., 2016).

Olfactory dimension

Pleasantness of smell had a significant effect on comfort. This is consistent with the idea that odors can elicit emotion and are linked to individuals' emotional memory (see, Kadohisa, 2013). If the properties of a pleasant smell for a teddy bear have not been identified, this result suggests that comfort potential is not limited to visual features. Olfaction plays a role in human relationships: in children, smell plays a role in identification and attachment to the caregiver (Maroni, 2015); in adults, it seems to influence mate choice and to enhance a feeling of social security (Croy et al., 2013). Thereby, objects with particular olfactory properties arouse comfort: for example, a common behavior in adults is to smell the clothes of the partner when she or he is away (Shoup et al., 2008). It is therefore understandable that the olfactory properties of teddy bears play a role in their comforting potential, and in the creation of a feeling of attachment and security. It would be interesting to develop this hypothesis by qualifying more specifically the pleasant smell of certain teddy bears (using for instance, Gas Chromatography Mass Spectrometry, Richter et al., 2018) and to whom or what they are associated.

Kinesthetic dimension

Softness appeared as the most important variable in the perception of comfort. Thus, it would seem that the comforting power of the teddy bear is transmitted mainly through touch. This agrees with the study conducted by Tai et al. (2011) in which adults find comfort in the touch of teddy bears in the face of a situation of social exclusion. In the same way, larger bears seem more attractive than smaller ones, probably because they are more pleasant to handle and cuddle, and therefore more comforting. The comforting potential of teddy bears would therefore be more related to their kinesthetic properties, i.e., the way in which one can interact with them (see also, Haynes et al., 2022). This is also consistent with the results of another study which reported that simply holding a teddy bear helps people with low self-esteem reducing existential fear (see Koole et al., 2014). As pointed out by Caldas-Coulthard and van Leeuwen (2003) the design of teddy bears is not only designed to be visually attractive, but also to highlight the importance of

interactivity, the embodied theory of emotion providing a strong framework to account for the comforting emotional interactive experience (see, Barrett & Lindquist, 2008). It is therefore through interactivity that an emotional bond is created and reinforced. However, the variable 'pleasant to manipulate' did not prove to be salient in the perception of comfort. It is probably a methodological bias: the term 'manipulate' was perhaps not clear in French, and understood in the sense of 'articulate'. We should have used the expression 'to cuddle' or 'to play with' instead.

Conclusion and perspectives

In conclusion, the comforting power of teddy bears lies firstly in the emotional bonds (observed through ownership effect), and secondly in a combination of visual, olfactory, and especially kinesthetic characteristics. Because many researchers mobilize the teddy bear to provide knowledge on the psychological functioning of individuals, future studies should pursue the study of its comforting power, but also attempt to extend the list of its relevant uses (i.e., at home, at school, in hospital). For example, one study highlighted that a teddy bear could be used to examine children's ability to detect emotional meaning in music (Boone & Cunningham, 2001). The kinesthetic dimension is of particular interest in this study since children had to make the teddy bear dance to signal the emotion children identified in different pieces of music. Others have questioned the property of the teddy bear in fictional stories to further examine whether young children are able to predict the emotional state of the character (Pesowski & Friedman, 2015). Teddy bears are also used in studies conducted to determine gendered versus neutral toy preferences (Stagnitti et al., 2010). Contrary to dolls and cars (Jadva et al., 2010) that are often used to show how sex differences in toys preferences arise from socialization or cognitive gender development rather than inborn factors, the teddy bear seems designed to fit with both boys' and girls' preferences. According to a recent meta-analysis (Davis & Hines, 2021), children's gender-related toy interests have remained stable over the last 50 years. Fortunately, the teddy bear avoids the pitfall of gender-stereotype and could be used both with boys and girls, as much with children as with adults. In the present study, the comforting score was not sensitive to gender, nor to participants' age, which is consistent with the idea that the cues used to attribute this comforting score does not change over time, and was not biased by any gender-stereotyped effect.

This study opens the way for further work to confirm and refine these results, knowing that this participatory

study would benefit from replication in a more rigorous laboratory setting. Determining the physical characteristics that contribute to the comforting power of a stranger bear is a challenge for all studies that rely on this artifact to gain insight into the psychological functioning of individuals. In this sense, the accumulation of evidence in favor of positive emotional outcome in situation involving the presence of a teddy bear can be seriously considered to add this artifact to the list of efficient experimental methods to induce positive emotional state (see Siedlecka & Denson, 2019 for a qualitative review of experimental induction procedures). If emotional bond is a dominant factor in assigning a comfort score, it might be possible to pursue this work by asking participants to rank their different own bears in order of comfort preference. By overriding the effects of ownership and emotional bonds, this protocol could enable the comparison of the classification criteria between foreign bears and bears belonging to their owner. Another promising line of research concerns the way children anthropomorphize the teddy bears. In one study, it has already been demonstrated that children are able to attribute emotional states to an inanimate object but only do so when the object is something of great emotional worth to them and has personifying features like a face (Gjersoe et al., 2015). The teddy bear, king of stuffed animals, has not finished making us do research, with the numerous advantages to exploit it in psychological studies.

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Data availability statement

Data associated with this paper can be found here in open access: <https://doi.org/10.6084/m9.figshare.19948322.v2>.

Open Scholarship



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Ethical statement

All the subjects have provided appropriate informed consent (see *Supplemental online material*) provided by the Data Protection Officer of the University of Montpellier, in accordance with the General Data Protection Regulation (European Regulation No. 2016_679_EU of 27 April 2016) and the law relating to data processing, files and freedoms (Law No. 78-17 of 6 January 1978). The survey conducted during this study is non-interventional and anonymous.

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