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Handedness and digit ratio predict overconfidence in cognitive and motor skill tasks in a sample of preschoolers

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Abstract

In a sample of 141 preschoolers, ages 4 to 6, we find children display overconfidence in cognitive and motor skill tasks, a result that replicates that of adults. Both set of findings suggest the bias may not be learned behavior. Moreover, we find right-handed children to display more overconfidence in the cognitive task, whereas low digit-ratio children show more overconfidence in fine and gross motor skill tasks. Handedness polymorphism has been linked to neurological differences, and in literature low digit ratios are commonly associated with high fetal testosterone.

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1. Introduction

That most people believe they are better drivers than others [1] is entertaining. It may be because intuitive judgment is often accompanied by excessive confidence in what we believe we know. Overconfidence refers to the tendency to overestimate our own abilities and knowledge [2]. Overconfidence relates to an inability to acknowledge the full extent of our ignorance and the uncertainty of the surrounding environment. We are then prone to overestimate how much we understand and to underestimate the role of chance. The automatic intuitive mind (sometimes called "System 1") also shows an illusory certainty of hindsight, which feeds overconfidence [3], [4]. System 1 naturally generates overconfident judgments because confidence is determined by the coherence of the best story we can create from the evidence at hand. As a result, we tend to put too much faith in intuitions that deliver predictions that are too extreme [4].

Overconfidence is also thought to affect experts because even their System 1 cannot be turned off. Those who acquire expertise usually also develop an enhanced illusion of skill and become unrealistically overconfident. However, there exists "diminishing marginal predictive returns from knowledge" [5]. Worse, experts can be more overconfident than lay people. Experts may not know the limits of their expertise and, in particular, tend to ignore the environment around them. Only in a high-validity environment (where there is rapid feedback coming from judgments) can expert intuition be trusted – experts perform poorly in low-validity environments, such as financial markets [6]. Here, there may be costly consequences for organizations that take the word of overconfident experts, such as CEOs or CFOs [7]. However, loss aversion (another bias generated by System 1) compensates for overconfident optimism, although there is no guarantee the biases will cancel out in every situation [4].

Overconfidence is perhaps the most robust finding in the psychology of judgment [8]. It is well established, for instance, that entrepreneurs and managers commonly fall victim to overconfidence [9]-[14]. However, overconfident investors are wrong most of the time when they are confident they are right [15]. This is troubling because whenever investor confidence outweighs investor accuracy, financial markets: overtrade, under-react to information [16], and become more volatile [17]. Overconfidence in performance estimation is not only present in the financial domain, but also has been documented in a variety of different domains [18].

One way of evaluating overconfidence is through questionnaires [19], which detect when the proportion of accurate judgments made by the participants is surpassed by the expected subjective probability of being correct [20]. One problem with questionnaires is that they are subjective, self-reported measures of knowledge about knowledge ("metacognition"). Thus, the findings of overconfidence in questionnaire studies can be questioned. (See a literature review in [21].) However, overconfidence can still objectively occur in motor skill tasks [18], [21].

Is overconfidence innate or is it learned behavior? Here, we sought to partially answer this question. One way to get a glimpse of the answer is to consider a sample of preschool-aged children, or, ideally, babies [22]. If child behavior departs from adult behavior then one may conjecture a characteristic is learned. Although there are studies on overconfidence in adolescents [23], to the best of our knowledge there is no study using preschool children. We then considered a sample of preschoolers (ages 4 to 6). Within this age range, children already consider themselves to be autonomous individuals separate from their mothers, capable of dealing with quantities and counting, and able to realize that events may have a cause. As the application of questionnaires would be unfeasible, we resorted to a simple cognitive task of counting and two other objective measurements of motor skill tasks. The children were categorized according to their gender, handedness, and 2D:4D digit ratio. These fixed somatic markers proved to influence behavior in our previous experiments: Handedness was linked to the manifestation of the endowment effect [24] and 2D:4D to the ability of delaying gratification [25]. We thus conjectured that these markers could be linked to overconfidence in children, one conjecture just investigated in adults [26].

As for the handedness polymorphism [27], left-handed people are believed to be neurologically different: They occupy the extremes of the distributions of a number of characteristics. Disproportionately, many left-handed people have IQs greater than 140, and are associated with musical talent and athleticism. However, left-handedness has also been linked to epilepsy, Down syndrome, autism and mental retardation.

The digit ratio refers to the relative lengths of the second and fourth fingers, and may be a marker of fetal testosterone levels [28]. Males tend to have lower 2D:4D ratios than females, and this seems to apply to both adults [29] and children [25], [30]. The key support for the hypothesis that the 2D:4D ratio reflects fetal testosterone comes from correlational evidence – the ratio co-varies with the number of polyglutamine CAG in exon 1 of the androgen receptor gene [31]. Although this finding can be disputed [32], [33], more robust evidence has emerged from the direct experimental manipulation of the 2D:4D ratio in rodents [34], [35] and the administration of the levels of exogenous testosterone in humans [36]. Examples of previous studies considering the effects of 2D:4D on economic behavior are given in references [37]-[47].

2. Materials and methods

The experiments took place at six kindergartens at five high-income schools and one lower-income school from September to December 2012 in the southern city Florianopolis, Brazil. A total of 141 children (67 males and 74 females), ages 4 to 6, participated (data available at http://dx.doi.org/10.6084/m9.figshare.1301501). The research was approved by the Ethical Committee at the Federal University of Santa Catarina (approval number: 057/08). Parents were asked to allow their children to participate before providing consent in writing.

The teachers first reported the handedness of the participants, and the experimenter (B.M.) then confirmed their answers by asking a child to draw on a sheet of paper, which is perhaps the best way to assess a child's hand preference [48]. Children's anonymity was preserved, and only their gender was recorded by the experimenter.

The digit ratio was measured by the experimenter after tracing the contour of each child's right hand on a sheet of white paper. Measuring with a caliper would be the most accurate method, but the principals refused it on the basis that it was time consuming, intrusive, and of poor pedagogical value. However, even if calipers were allowed, we suppose they would be difficult to use due to the short attention span of the children. Photocopying or scanning the young children's hands could be an alternative, but we discarded it because of the likeliness of blurred and unusable images. In the end, tracing around the fingers may represent the best-practice solution for 4 to 6 year olds. This was confirmed, as the children seemed very relaxed during the assignment, reflecting its ludic aspect. The experimenter also noted cooperation on behalf of the children, perhaps because this was not the first time they engaged in the activity; tracing their hands was previously introduced by most teachers in other contexts. There appears to be no consensus in literature about how to make the most accurate measurement of digit ratio [49]. Some favor the use of digital scans, while others prefer computer-assisted analysis of the raw physical measurements [50]. Moreover, some argue for the use of both hands [51], rather than only the right hand.

The principals generally agreed to allow the use of the time reserved for the activities of physical education for the experiments to take place. Sometimes, lunchtime was also used. The trials took place in several sessions and the children were exposed to three tasks. The first was cognitive; we investigated how children's fluent use of a basic numerical skill was related to their perceptions of confidence. The experimenter asked each child to count from one to 10, and then from 10 to one. Before the task, he assessed how a child judged his or her own numerical skill by asking the question:

> Task 1 (*cognitive*): "Will you succeed in counting from one to 10 and then from 10 to one without making a mistake?"

Most children failed in the first attempt of performing task 1 (and also performing tasks 2 and 3 below). When children did not succeed in one attempt, the experimenter offered them another. Up to three trials were allowed. We then concluded the tasks were hard for them. In such cases, we do expect overconfidence: It is well-established that participants tend to be overconfident when it comes to questions designated to be hard (and less confident for easy questions) [20].

The other two tasks involved fine and gross motor skills. A fine motor skill task requires the use of smaller muscle groups to be performed. And a gross motor skill task requires the use of large muscle groups. The second task was a mild balancing test. We understand this can be considered a fine motor skill task, which generally refers to the small movements of the hands, wrists, fingers, feet, toes, lips, and tongue. The experimenter marked on the floor using masking tape a straight line five meters long. The children were asked to walk on the line from the starting point to the end, and then return backwards. Before the task he individually asked each child:

> Task 2 (*fine motor skill*): "Will you succeed in walking on the line from the starting point to the end, and then returning backwards?"

The third task was a gross motor skill one: to skip. The experimenter performed 10 rope jumps in front of each child individually. Then, he offered the children a rope appropriate for their heights and asked them:

> Task 3 (*gross motor skill*): "Will you succeed in jumping rope 10 times without missing?"

Obviously it did not matter whether a child was able to perform a task. What mattered was the subjective judgment of ability, that is, how confident he or she was prior to the task. As observed, the tasks were designed to be difficult for the children. Interestingly, even when a child failed twice, he or she still was convinced of success for the next trial. And when asked by the experimenter, most of them were also sure they would perform better than their peers.

After the data were tabulated, we estimated a model to uncover the influence of candidate explanatory variables (gender, digit ratio and handedness) on the probability of a child showing overconfidence as follows:

$$\pi_{ij} = \beta_0 + \beta_1 g + \beta_2 d_j + \beta_3 h + \varepsilon_i , \qquad (1)$$

where $i = 1,2,3$. Variable π_{ij} is the probability of child j to show overconfidence in task *i*; β_0, β_1, β_2 and β_3 are coefficient vectors capturing the impact of changes in an explanatory variable on π_{ij}; *g* is a dummy for gender (female = 0; male = 1); d_j is the 2D:4D digit ratio of child *j*; *h* is a dummy for handedness (left-handed = 0; right-handed = 1); and ε_i is an error term.

Explanatory variable selection was conducted using stepwise, backward and forward regressions [52]. Table 1 shows the results.

Table 1. Explanatory variable selection considering equation (1)

Overconfidence test	β_0	β_1	β_2	β_3	p-value
Task 1 (cognitive)	–0.9555	†	†	3.0032	< 0.0001
Task 2 (fine motor skill)	27.9096	†	–27.6363	†	< 0.005
Task 3 (gross motor skill)	22.5046	†	–22.1592	†	< 0.012

Note:
† The coefficient does not take part in the best model from the stepwise, backward and forward regressions.

3. Results

The average 2D:4D ratio for the entire sample was 0.963. As expected and in accordance with previous studies [24], [28], the average ratio was smaller (mean = 0.943; SD = 0.027) for male children than that for female children (mean = 0.981; SD = 0.0140); mean-differences t test: p-value < 0.001. Importantly, none of the six kindergarten classes showed an average disparity in the measures of the finger lengths from the tracings.

In the entire sample, 105 children were right-handed (62 females and 43 males) and 36 were left-handed (25.5 percent; 12 females and 24 males). This result roughly matched that of another study [36], where children's hand preference was also verified through drawing and 27 percent were left-handed.

The presence of the overconfidence bias was massive across the three tasks (Table 2). As in adults, children were prone to the bias. This suggests overconfidence is unlikely to be learned behavior.

Table 2. Overconfidence in the three motor skill tasks

Task type	*Number of children displaying overconfidence*	*Percentage of total*
1. Count	103	73.05
2. Walk over a straight line	107	75.89
3. Skip	105	74.47

As for task 1, the use of the model in equation (1) allowed us to uncover the variable handedness as implicated in the bias ($p < 0.0001$; $z = 6.23$; $n = 141$). The estimated logistic equation (2) shows the significant result after considering gender, digit ratio and handedness as candidate explanatory variables:

$$\text{logit}\,\pi_{1j} = \log\frac{\pi_{1j}}{1-\pi_{1j}} = -0.9555 + 3.0032h\,. \tag{2}$$

Taking the logs on both sides, equation (2) becomes the probability:

$$\pi_{1j} = \frac{\exp\left(-0.9555 + 3.0032h\right)}{1+\exp\left(-0.9555 + 3.0032h\right)}\,. \tag{3}$$

Taking into account the data on handedness in equation (3), one can find the associated probability of child j to show overconfidence in task 1, after considering the value of zero for the left-handed and of one for the right-handed. We then find a child to be 89 percent likely to display overconfidence in the cognitive task if he or she was right-handed (Figure 1). Interestingly, this matched a similar result for adults [53], where professional investors who were right-handed were more likely to display overconfidence. In short, both left-handed children and adults are more likely to escape the bias. This may or may not be related to a left-handed neurological advantage in terms of a better cognitive reflex, which means a more tamed System 1. However, this conjecture is purely speculative and remains to be proved by future research.

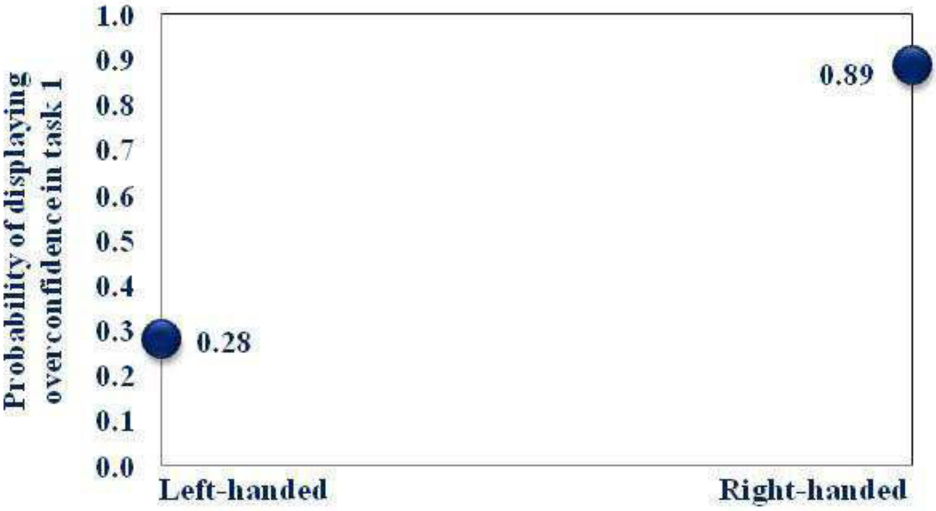

Figure 1. Probability of displaying overconfidence in task 1 (cognitive skill). The odds were higher (89 percent) if a child was right-handed (left-handed = 0; right-handed = 1).

Our model selected the digit ratio as implicated in the chances of a child to display overconfidence in task 2 ($p < 0.005$; $z = -2.82$; $n = 141$):

$$\text{logit}\,\pi_{2j} = \log \frac{\pi_{2j}}{1-\pi_{2j}} = 27.9096 - 27.6363 d_j, \quad (4)$$

which, after taking the logs on both sides, becomes:

$$\pi_{2j} = \frac{\exp\left(27.9096 - 27.6363 d_j\right)}{1+\exp\left(27.9096 - 27.6363 d_j\right)}. \quad (5)$$

Considering the 2D:4D ratio measures tabulated for the children in equation (5), one can find the associated probability of child j to show overconfidence in task 2. An inverse relationship between π_{2j} and d_j (Figure 2) emerged: The lower the digit ratio, the higher the odds of a child to display overconfidence in the fine motor skill task. This may also mean the higher fetal testosterone exposure, the higher the chances of a child to be overconfident in task 2.

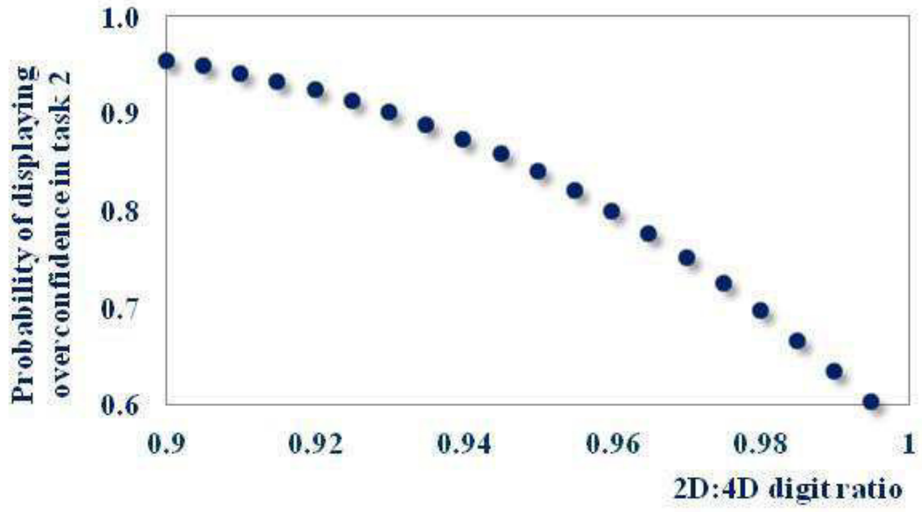

Figure 2. Probability of displaying overconfidence in task 2 (fine motor skill). The lower the digit ratio (the higher fetal testosterone exposure), the higher the odds of a child to display overconfidence.

The model also selected the digit ratio as an explanatory variable in task 3 ($p < 0.012$; $z = -2.50$; $n = 141$):

$$\text{logit}\,\pi_{3j} = \frac{\pi_{3j}}{1-\pi_{3j}} = 22.5046 - 22.1592 d_j . \tag{6}$$

Again, taking the logs on both sides, equation (6) becomes:

$$\pi_{3j} = \frac{\exp\left(22.5046 - 22.1592 d_j\right)}{1+\exp\left(22.5046 - 22.1592 d_j\right)} . \tag{7}$$

As in the fine motor skill task, there also emerged an inverse relationship between the probability of child *j* to show overconfidence in the task and child *j*'s digit ratio (Figure 3) in the gross motor task. Using equations (5) and (7), one can find that the probability of low digit-ratio children to display overconfidence in task 2 was 95 percent, whereas high digit-ratio children had a probability of 57 percent. In task 3, low digit-ratio children had a 93 percent probability of displaying overconfidence, whereas the probability for high digit-ratio children was 59 percent.

In sum, we find low digit-ratio (high prenatal testosterone exposure) children display more overconfidence in fine and gross motor skill tasks. This result contradicts a similar study that considers university students and finds low digit-ratio associated with less overconfidence [26].

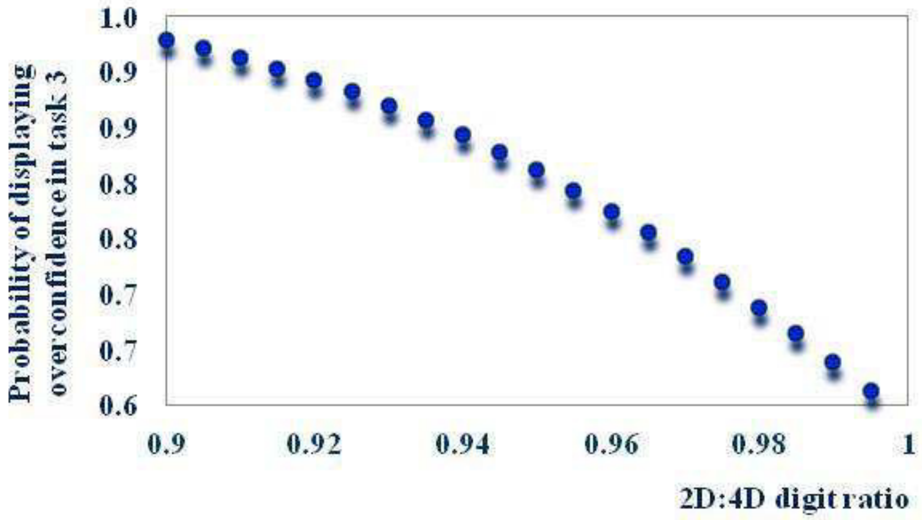

Figure 3. Probability of displaying overconfidence in task 3 (gross motor skill). The lower the digit ratio (the higher fetal testosterone exposure), the higher the odds of a child to display overconfidence.

4. Conclusion

This study considers children's overconfidence in an attempt to assess whether it is an innate or learned behavior. We find one cannot dismiss the bias as innate. We also relate the bias to fixed somatic markers: gender, handedness and 2D:4D digit ratio. In a sample of 141 preschoolers, ages 4 to 6, we find that right-handed children display more overconfidence in a cognitive task, whereas low digit-ratio (high prenatal testosterone exposure) children display more overconfidence in fine and gross motor skill tasks.

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