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Inhibition and cognitive flexibility are related to prediction of one’s own future preferences in young British and Chinese children

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24 **Abstract**

25 The ability to shift from current to future perspective is pivotal to future-oriented cognition.
26 However, the relationship between executive function, theory of mind and the ability to predict
27 future preferences of self and others has received little focus, particularly across different cultures.
28 With two distinct cultural groups in Britain (N = 92 participants) and China (N = 90), we
29 investigated 3 to 5-year-olds' understanding of their own versus a peer's current and future
30 preferences. We administered a battery of standardised executive function (inhibition, cognitive
31 flexibility, working memory) and theory of mind tasks to examine the underlying relationship
32 between these cognitive abilities and children's ability to predict future preferences. Consistent with
33 previous literature, we found significant age-related performance in the future preference task.
34 Furthermore, our study indicates that there may be a universal developmental trajectory in British
35 and Chinese children's future-oriented cognition. We found that children were more accurate when
36 predicting for their peers than predicting for themselves. Also, their performance improved when
37 they had the opportunity to identify their current preferences before anticipating the future. Chinese
38 children outperformed their British counterparts on cognitive inhibition and cognitive flexibility
39 tasks, with no country-related differences in their working memory, motor inhibition or theory of
40 mind ability. After controlling for age, children's performance in the inhibition and cognitive
41 flexibility tasks were significantly correlated with the prediction of their own – though not peer's -
42 future preferences. We discuss these findings in relation to the conflicts between multiple
43 perspectives and the cognitive correlates of future-oriented cognition.

45 **Keywords**

46 cognitive development, future-oriented reasoning, executive function, theory of mind, cross cultural
47 research

49 **Highlights**

- 50 • Children's future prediction was more accurate for peers than for themselves
- 51 • British and Chinese children performed comparably in predicting future preferences
- 52 • Inhibition and cognitive flexibility were related to predicting one's own future
- 53 • Theory of mind did not correlate with future preference prediction

55 **Introduction**

56 Thoughts about the future play an importance role in human lives, and anticipation of how the future
57 will unfold can influence behaviours in various ways (D'Argembeau, Renaud, & Van der Linden,
58 2011). From daily decisions as trivial as whether to bring an umbrella on a rainy day to more critical

59 long-term strategies of financial saving over impulsive purchases, future-oriented cognition pertains
60 to all aspects of life. The study of its cognitive and neural processes has become a focus over the past
61 decade. Researchers have revealed a common brain network involved in remembering memory and
62 imagining the future (Addis, Wong, & Schacter, 2007) as well as developed a battery of tasks to
63 assess the acquisition and maturation of future-oriented cognition in children (Atance, 2008;
64 McCormack & Hoerl, 2020; Suddendorf & Moore, 2011). Parallel to the development of many
65 cognitive milestones, preschool years have been found to be a critical period for children's
66 development of future-oriented cognition. Specifically, young children are able to delay immediate
67 gratification for better reward in future (Prencipe & Zelazo, 2005), select tools or save resources for
68 future needs (Atance, Metcalf, & Thiessen, 2017; Atance, Louw, & Clayton, 2015; Suddendorf,
69 Nielsen, & Von Gehlen, 2011; Russel, Alexis, & Clayton, 2010), anticipate physiological states
70 (Atance & Meltzoff, 2005), understand knowledge growth (Atance & Caza, 2018) and talk about
71 future events (Hudson, 2002; Zhang & Hudson, 2018).

72 Understanding that others may have different desires and beliefs and the ability to attribute
73 different mental states to other people is the foundation of human social life. Early research on
74 theory of mind (ToM) found that children as young as 18 months successfully infer diverse food
75 preferences to different people (Repacholi & Gopnik, 1997) and by age 3, children understand that
76 people have different desires about the same objects (Wellman & Bartsch, 1988; Wellman &
77 Woolley, 1990). In contrast, less is known about young children's reasoning of mental state changes
78 occurring within the same individual and within one's own self at different temporal points.
79 Children's current desires of objects were influenced by their own past experiences, yet 3-year-olds
80 failed to understand conflicting preferences and changes between past and current desires (Cassidy
81 et al., 1995; Gopnik & Slaughter, 1991).

82 Inaccurate prediction of how preferences, values and feelings change over time impair decision-
83 making, and among adults, there is a tendency to underestimate the extent of changes that often lead
84 to regrettable choices (Gilbert & Wilson, 2007; Quoidbach, Gilbert & Wilson, 2013). The
85 phenomenon of intensity bias in which emotional reactions to future events are overestimated is
86 present in both adults and pre-schoolers (Gilbert, Pinel, Wilson, Blumberg, & Wheatley, 1998;
87 Gautam, Bullet, von Hippel, & Suddendorf, 2017; Kopp, Atance, & Pearce, 2017). Furthermore,
88 future-oriented decisions are often shadowed by the current states and such "projection bias"
89 (Loewenstein & Angner, 2003) affects the anticipation of not only psychological states but also
90 physiological needs. For example, after consuming a salty pretzel, children predicted that they would
91 choose water over pretzel the next day, because they have projected their current feeling of being
92 thirsty into the future even though these states may change and no longer be relevant (Atance &
93 Meltzoff, 2006; Kramer, Goldfard, Tashjian, & Lagattuta, 2017; Mahy, 2016; Mahy, Grass, Wagner,
94 & Kliegel, 2014).

95 A recent line of research has focused on children's reasoning of changes in preferences,
96 specifically the contrast between current and future preferences (Atance, Rutt, Cassidy, & Mahy,
97 2021; Bélanger, Atance, Varghese, Nguyen, & Vendetti, 2014; Lee & Atance, 2016; Kopp, Hamwi,
98 & Atance, 2021). In the original future preference task (Bélanger et al., 2014), pre-schoolers were
99 shown child-preferable and adult-preferable items and asked to choose what they preferred currently
100 (self-now trials) and in the future (self-future trials). The researchers found an age-related
101 developmental trajectory, namely that older children were increasingly better at predicting that they
102 would hold different preferences when they were grown up, whereas 3-year-olds' decisions on future
103 preferences were largely restricted by their current preferences. Additionally, children's ability to
104 understand preference changes occurring within another individual (a same-aged peer) was assessed
105 and the findings indicated similar age-related changes in performance (Bélanger et al, 2014; Lee &
106 Atance, 2016).

107 Furthermore, there is an "other-over-self" advantage in which pre-schoolers were more accurate
108 at predicting the future preferences of their peers compared to themselves (Bélanger et al, 2014).
109 Such an effect has been found in subsequent studies adopting the same paradigm (Bauckham et al.,
110 2019; Lee & Atance, 2016; Renoult, Kopp, Davidson, Taler, & Atance, 2019), as well as tasks
111 assessing the different component of children's future-oriented cognition. Notably, Russell et al.
112 (2010) designed a "blow football task" which required children to select items for future use and 4-
113 year-olds (but not 3- or 5-year-olds) were better at choosing the correct items when selecting for
114 another child. Similarly in a different experiment, children aged between 3 and 7 years had difficulty
115 overcoming their salient state of thirst, which impaired their future predictions but had more success
116 when predicting for another individual, i.e. the experimenter (Mazachowsky, Koktavy, & Mahy,
117 2019).

118 Several researchers have argued that the conflicts experienced by children between their current
119 states and future states underlie their difficulty of accurate future-oriented reasoning (Atance &
120 Meltzoff, 2006; Bélanger et al., 2014; Atance et al., 2021). When adopting the alternative
121 perspective of a third person, such as a same-aged peer, a "psychological distance" from one's own
122 perspective was created thus reducing the cognitive resources to coordinate the different perspectives
123 and facilitates children's prediction of future psychological and physiological needs (Lee & Atance,
124 2016; Mazachowsky et al., 2019). Another way to improve children's anticipation of future states is
125 to satiate their current desires. Pre-schoolers were more likely to select the age-appropriate gift for
126 their mothers as opposed to their own desired object when they were first asked to choose a gift for
127 themselves (Atance, Bélanger, & Meltzoff, 2010). More remarkably, even the anticipation of desire
128 fulfilment elevated children's performance. A similar effect was found with the future preference
129 task: children who were asked to indicate their current preferences before predicting the future

130 preferences outperformed their peers who were first asked to select the items they would like in the
131 future (Bélanger et al., 2014).

132 A potential route to reduce the conflicts between the different perspectives is to inhibit irrelevant
133 thoughts and perceptions from one perspective to interfere with the reasoning of the other
134 perspective. Several researchers have linked executive function with future-oriented cognition and
135 neuroimaging findings suggest that these two cognitive abilities share overlapping cortical areas
136 such as frontal and prefrontal substrates (Addis et al., 2007; Atance & Jackson, 2009; Buckner &
137 Carroll, 2007; Suddendorf & Corballis, 2007; Szpunar, Spreng, & Schacter, 2014). Executive
138 Function (EF) refers to a set of higher-order cognitive abilities and it has been considered as a
139 unitary construct in children comprising three key components, namely working memory, cognitive
140 flexibility and inhibition (also referred as inhibitory control) (Hughes, 2011; Miyake et al., 2000).

141 Theoretically, each EF component has been hypothesized to relate differently to future-oriented
142 cognition. The most intuitive link lies between inhibition and future-oriented cognition as the former
143 depends on the control of attention and behaviours to suppress prepotent responses and select the
144 more appropriate responses for different circumstances (Diamond, 2013). Inhibition is highly
145 relevant in future-oriented scenarios when both the current and future perspectives are involved and
146 people need to put aside their current feelings and desires to make adaptive decisions (Hanson,
147 Atance & Paluck, 2014). Working memory involves holding and updating information and cognitive
148 flexibility entails the capacity to switch between perspectives and adjust behaviours to changed
149 demands. When thinking of the future, it is important to keep track of multiple perspectives while
150 being able to flexibly shift and coordinate the different demands.

151 A few studies have empirically examined the relationship between future-oriented cognition and
152 EF ability, with mixed results. Ünal and Hohenberger (2017) adopted a modified version of the
153 “blow football task” and found children’s ability to select items for future use was related to
154 inhibition and spatial working memory after controlling for age. Moreover, performance on a
155 prospective memory task was positively predicted by school-age children’s inhibition control (Ford,
156 Driscoll, Shum, & Macaulay, 2012). Contrarily, there was no link between children’s performance
157 on a future planning task in a tool-use context and EF competency (Miller et al., 2020). With a
158 battery of tasks measuring future-oriented cognition and EF ability, Hanson and colleagues did not
159 find significant inter-task correlations among pre-schoolers (Hanson et al. 2014).

160 The disparity of results may be attributed to the task demands of the different future-oriented
161 tasks. Specifically, past studies adopted tasks that assessed children’s ability to plan and remember
162 future events, which does not necessarily entail conflicts between the current and future perspectives
163 (Ford et al., 2012; Hanson et al., 2014; Miller et al., 2020). Research has shown that EF is most
164 relevant when cognitive resources are actively employed to switch and coordinate different
165 perspectives especially when one’s own perspective is involved (Fizke, Barthel, Peters, & Rakoczy,

2014). For example, scenarios in the future preference task where children were asked to choose the items they like in future as opposed to their current desire of the child-typical items (Bélanger et al., 2014).

Recently, Atance et al. (2021) manipulated the level of conflicts between the current and future perspective in several future-oriented tasks, including the future preference task, and examined the association between future-oriented reasoning and inhibition competency. After controlling for age, there was a significant relationship between children's performance on inhibitory control tasks and their anticipation of future physiological states and need of tools, though not with their prediction of future preferences. However, Atance et al. (2021) only measured one aspect of executive function - children's inhibitory control - neglecting the potential role of cognitive flexibility and working memory in children's future-oriented reasoning.

In addition to EF, researchers have considered ToM as an important scaffolding ability and cognitive correlates in young children's development of future-oriented cognition (Atance & Jackson, 2009; Atance & O'Neill, 2005; Suddendorf & Corballis, 2007). In particular, these two cognitive abilities share common brain areas and emerge around the same time in preschool years (Atance, 2008; Carlson & Moses, 2001; Hanson et al., 2014; Spreng, Mar, & Kim, 2009). ToM refers to the ability to perceive and attribute different internal mental states in oneself and others which entails the understanding of desires, beliefs, emotions, knowledge and intentions (Wellman, Cross, & Watson, 2001). Buckner & Carroll (2007) proposed that self-projection is a common mechanism underlying peoples' thoughts about the future and of another person. Intuitively, the centrality of both cognition involves shift in perspectives; in ToM it is the shift between one's own mental states to others' whereas with future-oriented cognition it is the projection from current standpoints to future perspectives. Thus, a better understanding of how mental states differ among people could, in principle, transfer or facilitate the ability to anticipate mental state changes within the same person at different temporal points.

Several studies have empirically tested the relationship between children's ability to make future-oriented decisions and their ToM task performance. Notably, children's performance in the widely used "false belief" task was related to their saving behaviours for future resources (Metcalf & Atance, 2011) as well as their capacity to remember and act upon future events (Ford et al., 2012). However, Hanson et al. (2014) failed to find an association between standardised ToM tasks and a range of task measuring different aspects of future-oriented thinking. Reasons underlying such mixed findings may be that the extent of perspective shift was different between the tasks. Notably, in the classic ToM task, children were asked about another child's mental states which was in direct contrast of their own. For instance, in the false belief content task, the child knows that the objects within an egg box are toy balls while children who have not seen inside the box believed they are eggs. This is different from some future-oriented tasks that do not involve the distinction between

the current perspective and future viewpoints, such as requiring children to plan for a zoo visit with sequential steps (McColgan & McCormack, 2008) or imagining themselves in different environments to anticipate physiological needs like the “picture book” task (Atance & Meltzoff, 2005). Therefore, further investigation is needed to elucidate the relationship between future-oriented cognition and ToM ability. Specifically, it is important to match the inter-task demand of perspective shifting between the measures.

A noteworthy characteristic of the research on children’s future-oriented cognition is that the data has primarily come from European-American countries, so that our knowledge of its developmental trajectory and cognitive correlates may be culturally skewed and biased (Nielsen & Haun, 2016). Cognitive development is acknowledged as a malleable and context-specific process that is sensitive to social and cultural influences and there has been growing effort to advocate researchers to examine cognitive development outside Western societies (Henrich, Heine, Norezayan, 2010; Wang, 2016). To date, one consistent finding is that pre-schoolers from East Asian countries typically outperform their Western peers on measures of EF, especially on inhibition task (Oh & Lewis, 2008; Lan, Legare, Ponitz, Li, & Morrison, 2011; Lewis, et al., 2009; Moriguchi, Evans, Hiraki, Itakura, & Lee, 2012; Sabbagh, Xu, Carlson, Moses, & Lee, 2006; Thorell, Veleiro, Siu, & Mohammadi, 2013; Schmitt et al., 2019, for a review see Schirmbeck, Rao, & Maehler., 2020). Such a cultural contrast has been interpreted as the reflection of the differences between individualist culture and collectivistic culture as well as the emphasis of self-control in school environment and parenting behaviours in Asian countries (Chen et al., 1998; Eisenberg, Chang, Ma, & Huang, 2009; Ellefson, Ng, Wang, & Hughes, 2017; Liu et al., 2005; Xu, Ellefson, Ng, Wang, & Hughes, 2020).

Similarly, researchers have found cross-cultural variations between children’s ToM performance, yet the findings were more mixed (for a meta-analysis, see Liu, Wellman, Tardif, & Sabbagh, 2008). Early studies have demonstrated that children from the Western societies were better at understanding and attributing different mental states than Eastern children (Sabbagh et al., 2006; Vinden, 1999), while there were also differences within Asian countries, such as Korean and Japan (Oh & Lewis, 2008). In addition to the acquisition of ToM ability, often marked by passing the false belief task, researchers have developed a scaling task that consisted of the sequential developmental steps (Wellman & Liu, 2004). A salient and intriguing finding was that the earliest evidence of ToM ability in Chinese and Iranian children loaded on their understanding of diverse knowledge, while, for Western children, it loaded on diverse beliefs (Shahaeian, Peterson, Slaughter, Wellman, 2011; Wellman, Fang, Liu, Zhu & Liu, 2006).

To the best of our knowledge, only one study has examined and compared future-oriented cognition between different cultures. Redshaw et al. (2019) tested children from three cultural groups: Australia (Brisbane), Indigenous Australians and South African Bushman. Children completed a task that assessed their ability to understand and prepare for alternative future

possibilities when an item was dropped into a forked tube with two open ends. Despite some differences in the youngest age groups approaching ceiling performance, overall, there was no specific cultural contrast, which may indicate universal developmental maturation. However, with only one cross-cultural comparison, further research is required as there may be robust cultural variations in other components of future-oriented cognition, or other cultures.

We aimed to address these gaps in the literature with the following three aims. The first aim was to adopt the future preference task (Bélanger et al., 2014) to test three to five-year old children's reasoning about their desired objects while conflicting perspectives were involved. Specifically, this task involved two baseline conditions focussing on current preferences (self-now, peer-now) and three experimental conditions with two test conditions focusing on future preferences (self-future and peer-future) and one control condition assessing children's general knowledge of adults' preferences (adult-now). We counterbalanced the order of testing so half of the children received the baseline-experimental conditions, while the other half received the experimental-baseline conditions. Unlike previous related studies, we used a within-subjects design for conditions, reducing any potential participant variation between groups. Pictures of random adults were used in previous studies (Bélanger et al., 2014) when questions about future preferences were asked. We simplified the procedure in the current study by only including verbal instructions in the future-related trials. Young children have been shown to understand temporal references and concepts, such as "adult" and "when you grow up in future" (Tillman, Marghetis, Barner, & Srinivasan, 2017), and other lines of research on children's future-oriented cognition has predominately adopted verbal instructions (McCormack & Hoerl, 2020). Therefore, it was worthwhile investigating whether changing the instruction format would influence children's reasoning of future preferences.

The second aim was to investigate the link between EF (working memory, inhibition, cognitive flexibility), ToM and children's prediction of preference changes, using a comprehensive battery of standardised tasks, in British and Chinese pre-schoolers. The third aim was to compare British and Chinese pre-schoolers' future-oriented cognition to a) test Chinese pre-schoolers, as they have not been tested with this future preference task previously, and b) compare any developmental trajectory with British counterparts. British children and Chinese children represent a Western and Eastern culture. Notably, these two groups have been shown previously to differ in their EF and ToM abilities (Hughes, Devine, & Wang, 2018; Xu et al., 2020). It is worth emphasizing that the future preference task was of particular interest and relevance for cross-cultural research. That said, to compare performance on the task between two samples of children who have shown developmental variability on EF and ToM, indeed the two cognitive abilities theorized to underline the development of future-oriented cognition.

Based on previous literature in the future preference task, we predicted that pre-schoolers would perform better when predicting the future preferences for a same-age peer (peer-future condition)

over predicting for themselves (self-future condition) (Bélanger et al., 2014; Lee & Atance, 2016). Children who were asked to identify their current desires (baseline conditions) before anticipating their future preferences (test conditions) would have higher performance than those who predicted their future preferences before answering their current ones. With regards to the relationship between children's ability to understand preference changes and their EF and ToM task performance, we did not hold specific predictions taken consideration of the limited literature with mixed findings. However, we did expect that British and Chinese children may differ in their EF performance, specifically with Chinese children outperforming their British counterparts in inhibitory control tasks (Lan et al., 2011; Sabbagh et al, 2006). Finally, we predicted that the children from both countries would show similar age-related performance and developmental trajectories in their understanding of preference changes within themselves and another individual.

Methods

Participants

The participants were 182 children aged between three and five-years-old. In Britain, we recruited 92 children: 30 3-year-olds (Mean = 3.54 years, Range = 3.03-3.98 years), 32 4-year-olds (M = 4.43 years, R = 4.01-4.95 years) and 30 5-year-olds (M = 5.40 years, R = 5.03-5.90 years), of which 43 were male and 49 were female. The British participants were recruited at nurseries and schools in Somerset and central London, which served predominantly white, middle-class backgrounds. In China, 90 children took part in the study: 30 3-year-olds (M = 3.56 years, R = 3.05-3.99 years), 30 4-year-olds (M = 4.59 years, R = 4.09-4.99 years), 30 5-year-olds (M = 5.59 years, R = 5.15-5.97 years), of which 46 were male and 44 were female. The Chinese participants were recruited at university affiliated nurseries with Chinese middle-class backgrounds in Kunming, Yunnan Province. The UK data collection took place from March to July 2019, and the Chinese data collection took place from October to December 2019.

Ethics

All procedures performed in the present study were in accordance with the ethical standards of and were approved by the University of Cambridge Psychology Research Ethics Committee (PRE.2017.108). Information sheets and consent forms were provided to parents and written parental consent was obtained prior to participation of the children. We also obtained written consent from parents to video-record the experimental sessions.

Procedure

The study included a single experimental session of 45 minutes and children were tested individually with a female experimenter in a separate room to the main classroom within the nurseries and

schools. In addition to Bélanger et al.'s future preference task (2014), we administered a battery of representative tasks of EF and ToM. Specifically, the EF tasks were tests of inhibition (Day-Night, Gerstadt, Hong, & Diamond, 1994; Knock-Tap, Luria 1996), working memory (Spin the Pots, Hughes & Ensor, 2005), and cognitive flexibility (Dimensional Change Card Sort Task, DCCS, Zelazo, 2006). Children's ToM ability was measured with tasks of Diverse Desire (Wellman & Liu 2004), Diverse Belief (Wellman & Liu, 2004), Knowledge Access (Pratt & Bryant, 1990), False Belief Content (Flavell, Green, & Flavell, 1989) and False Belief Location (Baron-Cohen, Leslie, & Frith, 1985). The brief task descriptions were outlined in Table 1 and the detailed administration protocols were included in Appendix A. All participants completed the future preference task first followed by the battery of EF and ToM tasks in a fixed order (Table 1).

320

321 **Future Preference Task (adapted from Bélanger et al., 2014)**

322 The future preference task assessed pre-schoolers' understanding of changes in their preferences, specifically that their current ones would be different from their own future preferences. This task has also been used to test young children's understanding of preference changes within another individual, i.e. a peer. The task involved presenting children with various pairings of items and asked them to choose the item that they liked for themselves or for a peer.

327 The future preference task consisted of baseline conditions and experimental conditions, and children were given specific verbal instructions accordingly. There were 2 baseline conditions involving questions of current preferences. Specifically, in the self-now baseline conditions, the children were asked about their *own* current preferences: "Which one do you like best right now, a picture book or a newspaper?". In the peer-now baseline condition, children were asked about the current preference of a same-aged and same-sex peer - example: "Sally is a little girl and she is 4-year-olds. She is just like you. Which one does she like best right now, an animal puzzle or a crossword?". The experimental conditions included two test conditions, namely the self-future condition and the peer-future condition, and one control condition of adult-now. In the self-future test condition, children were told: "Right now, you are 3/4/5 years old. But one day, you will grow up and become an adult. You are going to be as big as your mummy and daddy and your teachers. I am going to show you some things and I want you to tell me which one you will like best in the future when you grow up, a picture book or a newspaper?". In the peer-future test condition, the questions were about the future preferences of a same-aged and same-sex peer and the instructions were: "Sally is a little girl. She is 3/4/5 years old right now and she is just like you. But one day Sally will grow up and become an adult. She will be as big as your mummy and daddy and your teachers. I am going to show you some things and I want you to tell me which one Sally will like best in the future when she grows up, an animal puzzle or a crossword?". In addition to these two test conditions of future preferences, we used an adult-now control condition to test children's

Table 1. Brief descriptions for executive function (EF) and theory of mind (ToM) tasks.

Task	Description
EF task	
Day-Night (Gerstadt, Hong, & Diamond, 1994)	Child was instructed to say “Day” when presented with a picture of Moon and to say “Night” when presented with a picture of Sun. 351
Knock-Tap (Luria, 1966)	Child was asked to perform the opposite hand movement from the experimenter, for example to tap the table with flat palm when the experimenter knock on the table.
Spin the Pots (Hughes & Ensor, 2005)	Child was instructed to find stickers hidden underneath cups of different colours on a lazy Susan tray.
DCCS (Zelazo, 2006)	Child was instructed to sort cards by one rule (colour) and then was asked to sort cards by a different dimension (shape).
ToM task	
Diverse Desire (Wellman & Liu, 2004)	Child was asked to choose a drink for a puppet whose preference was stated to be the opposite of their own desire.
Diverse Belief (Wellman & Liu 2004)	Child indicated where a puppet would look for a bunny after being told the puppet hold the opposite belief to themselves.
Knowledge Access (Pratt & Bryant, 1990)	child saw inside a box which contains a toy dinosaur, and then was asked whether a puppet who had not seen inside the box know what was inside.
False Belief Contents (Flavell, Green, & Flavell, 1989)	child saw inside an eggbox which contained unexpected item of bouncing balls and child were asked whether a friend who has not seen inside the box know what the content would be.
False Belief Location (Baron-Cohen, Leslie & Frith, 1985)	The classic “Sally-Ann” task which assessed child’s understanding of mental states in different people with false belief questions.

understanding of what adults generally like. Children were told: “You are 3/4/5 years old and you are a child. Your Mommy, daddy and the teachers are much bigger and older, and they are adults. I am going to show you some things and I want you to tell me which one do adults like, Bing or gardening shows?”.

Each condition consisted of 5 trials and children completed all 5 trials in one block. In each trial, the experimenter presented two identical exemplars of a child-preferable item and two identical

exemplars of an adult-preferable item. Pairs of items, rather than single items, were used so that children did not perceive the task as involving limited resources. We adopted a within-subject design and each participant completed all conditions. We manipulated the order in which children received the baseline conditions (self-now and peer-now) and test conditions (self-future, peer-future, adult-now). Half of the children were first asked about the current preferences then future preferences, and vice versa for the other half of children. Notably, we fully counterbalanced the order in which children were asked about their own preferences or peer's preferences in the baseline conditions, as well as the order of conditions of self-future, peer-future and adult-now in the experimental conditions. Furthermore, the order of item presentation and verbal introduction of the child-typical item and adult-typical item were counterbalanced.

In total, we prepared 15 pairings of items created across 3 different categories with 6 pairs in the Drink & Snack category, 5 pairs in the Reading & Watching category, and 4 pairs in the Leisure & Game category. Each pairing of items consisted of one typical adult or adult-preferable item and one typical child or child-preferable item. The two items in one pairing were from the same category but were typically preferred or consumed by different age groups, for example, the "Peppa pig" smoothie versus "Starbucks" coffee in the Drink & Snack category. The 15 pairings were then evenly grouped into 3 sets with 5 pairings in each group, and we ensured that each group covered all three categories of items. Across the 3 groups of item pairings, one group was used for the self-now and self-future condition, one for the peer-now and peer-future condition and one for the adult-now condition. For the self and peer conditions, the same pairings of items were used respectively. The aim was to measure whether children chose child-typical items for their current preferences in the baseline trials, and understand that their future preferences would be different by selecting the corresponding adult-typical items in the test trials. We counterbalanced the 3 groups of item pairings across conditions so that the children in the same condition would be presented with different item pairings to minimise any potential influence of specific item category or pairings. To accommodate any potential cultural differences in the popularity and familiarity of items, we first conducted pilot work in the UK and China to ensure the selected items were suitable and representative. A full list of item pairings is presented in Appendix B (Table B.1).

Analyses plan for the Future Preference, EF and ToM tasks

In the future preference task, there were 5 baseline trials each for the self-now and peer-now conditions. Children's choices on any given self-future and peer-future test trials were only included in the analysis if the child-preferable item was chosen on the corresponding baseline trials. Therefore, this approach excluded the cases in which children may have selected the adult-preferable items in the test trials due to their atypical current preferences rather than adopting the future perspective of self and peer. The majority of children successfully selected the child-typical items

for themselves (UK 95.6% children; China 83.4% children) and for peers (UK 88.3% children; China 91.1% children) in the baseline conditions, choosing either 4 or 5 child-preferable items correctly. We live coded as well as video recorded all experimental sessions unless parents requested no recording. Cohen's Kappa test shown excellent inter-observer rating agreement, $\kappa = .902$, $p < .001$.

We adopted two scoring methods to analyse children's performance in the future preference task. Specifically, we first recorded the choice per trial for each participant as "correct" or "incorrect" and every single trial was used for the Generalized Linear Mixed Models (GLMM). GLMM has been suggested to be statistically robust in analysing binary data with unequal trials for each subject (Ibrahim, Chen, & Lipsitz, 2001; Ng, Carpenter, Goldstein, & Rasbash, 2006), which was particularly suitable for the future preference task as the number of test trials for each child depended on their performance in the baseline conditions. Second, consistent with existing research (Atance et al., 2021; Bélanger et al., 2014; Lee & Atance, 2016; Kopp et al., 2021), we calculated children's scores based on proportional measures by dividing the number of correct test trials in the self-future and peer-future conditions by the number of child-preferable items selected on the corresponding baseline conditions. For the adult-now control condition, we divided the number of correct trials by the number of total trials (out of 5). The proportional scoring method resulted in a single score ranging from 0 to 1 per experimental condition per participant. This approach allowed us to conduct post-hoc comparisons between different experimental conditions and correlational analysis between performance in the future preference task, EF and ToM tasks.

We conducted GLMM analysis (using R version 3.4.3) to assess which factors influenced children's success rate in the future preferences task. Success was a binary variable indicating whether the participant correctly solved the trial (1) or not (0), and was entered as a dependent variable in the models. We included the random effect of participant ID, fixed effects of age in years (categorical: ages 3-5 in individual years), condition (self-now, peer-now, self-future, peer-future, adult-now), country (China, UK), sex (male, female), order (baseline then test, test then baseline), trial type (baseline, test) and trial number (1-25). We ran two separate models: 1. all trials; 2. test trials. We used likelihood ratio tests to compare the full model (all predictor variables, random effects, and control variables) firstly with a null model, and then with reduced models to test each of the effects of interest (Forstmeier & Schielzeth, 2011). The null model consisted of random effects, control variables and no predictor variables. The reduced model comprised of all effects present in the full model, except the effect of interest (Bates, Kliegl, Vasishth, & Baayen, 2015). We then ran further exact two-tailed post-hoc comparisons for significant factors with proportional scores using Wilcoxon signed ranks tests, and compared performance against chance using binomial tests. The experimental conditions were of key interest in the current study therefore we present GLMM results based on children's responses in the experimental conditions in the manuscript and included the results for the experimental and baseline trials combined in Appendix C (Table C.1) for

completeness.

Raw scores of children's performance on the EF tasks were normally distributed yet failed the assumptions for parametric analysis, therefore we adopted the non-parametric Kruskal-Wallis and Mann-Whitney U tests to investigate the effect of age on children's EF task performance. Success in the ToM tasks were binary outcomes and Chi-square tests were conducted to examine which factors affected the children's task performance. Composite scores of EF and ToM were created by firstly averaging the raw scores across all the tasks then converting them to standardised Z scores. With a similar method, we also created the composite score of inhibition for the Day-Night task and Knock-Tap task.

For the correlational analysis, we investigated the relationship between children's performance in the future preference task with children's scores in the EF and ToM tasks. Notably, Pearson product-moment correlations were conducted for tasks measured or recorded in interval scale. These included the proportional scores of self-future and peer-future conditions and each EF task as well as the EF composite score, inhibition composite score and ToM composite score. Spearman's rho analysis was conducted to examine the relationship between the children's performance in the self-future and peer-future conditions in the future preference task and the individual task of the ToM, which were recorded in ordinal scale.

RESULTS

Children's performance in the future preferences task

In the experimental trials only, the full model differed significantly from the null model ($X^2 = 331.41$, $df = 6$, $p = <0.001$). We found significant main effects of **age in years**, **condition** and **order** on success rate (Table 1). There were no significant main effects of country or sex on success rate. Specifically, performance improved with age (Fig 1), and children in order 1 (baseline-experimental) outperformed than those in order 2 group (experimental-baseline) (Fig 2). Specifically, across all experimental trials, children's performance improved with age (Mann-Whitney U test: 3 vs 4 years: $U = 1158.50$, $z = -3.604$, $p < .001$; 3 vs 5 years: $U = 507.50$, $z = -6.846$, $p < .001$; 4 vs 5 years: $U = 1097.50$, $z = -3.982$, $p < .001$). Performance was higher in baseline than in experimental trial types (Wilcoxon signed ranks test: $z = -7.905$, $p < .001$).

Table 1. Generalized linear mixed models on factors affecting success rate (test trials) in future preference task in children (n = 182). P-values <0.05 are highlighted in bold.

Fixed term	Estimate	z-value	p-value
Age in years	1.439	9.081	<0.001
Condition	0.993	13.659	<0.001
Order	-1.047	-6.958	<0.001
Country	-0.016	-0.142	0.887
Sex	-0.110	-0.762	0.446

Fig. 1. Children’s proportional score for each age group by experimental conditions. Error bars represent standard errors of the mean proportional score. Reference line corresponds to chance responding (i.e. mean proportional score of 0.5).

Fig. 2. Children’s proportional score for testing order 1 (baseline-experimental) and testing order 2 (experimental-baseline) by test conditions. Error bars represent standard errors of the mean proportional score. Reference line corresponds to chance responding (i.e., mean proportional score of 0.5).

Within the experimental conditions, performance was higher in the control condition (adult-now), compared with the self- and peer-future test conditions (Wilcoxon signed rank test: self-future vs adult-now: $z = -7.456$, $p = <.001$; peer-future vs adult-now: $z = -4.067$, $p = <.001$). Within the test

conditions, children performed better when asked about future preferences of peers (peer-future) than their own future preferences (self-future) (Wilcoxon signed rank test: $z = -5.885$, $p < .001$). Furthermore, binomial tests were conducted to compare children's performance against chance level (set at 0.5). We found that all age groups' success rate were above chance level ($p < .001$), except for the 3-year-olds in the experimental-baseline order ($p = .056$).

Descriptive, developmental and cultural contrast analysis for EF and ToM tasks

Descriptive statistics of children's performance on the executive function (EF) and theory of mind (ToM) assessments were presented in Table 2. Mann Whitney U tests and Chi-square tests indicated that children's performance did not vary as a function of sex, so we collapsed across data for all subsequent analysis ($ps > .05$). Overall, there were significant developmental changes with older children showing increasingly higher performance in all EF and ToM tasks (Table 2). Specifically, across countries, 5-year-olds significantly outperformed 4-year-olds and 3-year-olds respectively on all EF tasks (all $p < .01$), as well as in all ToM tasks (all $p < .001$). Notably, we found a significant **country** effect that Chinese preschoolers outperformed their British peer on the *Day-Night* task (Mann Whitney U test: $\chi^2 = 2.955$, $n = 182$, $df = 1$, $p = .003$) and DCCS task (Mann Whitney U test: $\chi^2 = 3.242$, $n = 182$, $df = 1$, $p = .001$). Specifically, Chinese 3-year-olds and 5-year-olds scored higher than their British peers respectively on the Day-Night task with no significant country difference between the 4-year-olds (Mann-Whitney U test: Chinese 3-year-olds vs British 3-year-olds: $z = 2.439$, $p = .015$; Chinese 4-year-olds vs British 4-year-olds: $z = 1.411$, $p = .158$; Chinese 5-year-olds vs British 5-year-olds: $z = 2.855$, $p = .004$).

Additionally, Chinese 4-year-olds and 5-year-olds had better performance on the *DCCS* task than the British children while no differences between the youngest age group were detected (Chinese 3-year-olds vs British 3-year-olds: $z = 0.374$, $p = .709$; Chinese 4-year-olds vs British 4-year-olds, $z = 3.524$, $p < .001$; Chinese 5-year-old vs British 5-year-olds: $z = 3.353$, $p < .001$). There was no significant difference between Chinese children and British children in terms of their competency in the *Knock-Tap* task and *Spin the Pots* task ($\chi^2 = 1.236$, $p = .216$; $\chi^2 = 1.429$, $p = .153$). With respect to each ToM task and the composite ToM score, children's performance did not vary as a function of country (Chi-square test: all $p < .05$).

Table 2. Descriptive statistics and effects of age on executive function (EF) tasks and theory of mind (ToM) tasks.

Task	3-year-olds	4-year-olds	5-year-olds	Age effects
<i>EF tasks</i>				
Day-Night (range = 4-16)	9.32(2.78)	11.61(2.67)	13.82(1.92)	χ^2 (2, $n = 182$) = 57.965***

Knock-Tap (range = 4-15)	10.15(2.66)	12.27(2.17)	13.80(1.46)	χ^2 (2, n = 181) = 53.588***
Spin Pots (range = 4-12)	7.02(2.18)	8.76(2.45)	10.32(1.73)	χ^2 (2, n = 182) = 49.836***
DCCS (range = 0-6)	3.40(1.28)	4.92(1.46)	5.58(.96)	χ^2 (2, n = 182) = 73.037***
ToM tasks				
Diverse Desire (range = 0-1)	.77(.43)	1(0)	1(0)	χ^2 (2, n = 182) = 30.84***
Diverse Belief (range = 0-1)	.63(.49)	.77(.42)	1(0)	χ^2 (2, n = 182) = 25.89***
Knowledge Access (range = 0-1)	.27(.47)	.73(.45)	1(0)	χ^2 (2, n = 182) = 73.02***
False Belief Content (range = 0-1)	0 (0)	.32(.47)	.80(.40)	χ^2 (2, n = 182) = 83.09***
False Belief Location (range = 0-1)	.12(.32)	.55(.50)	.87(.34)	χ^2 (2, n = 182) = 68.06***

Note. Kruskal-Wallis tests were conducted for EF tasks and Chi-Square tests for the ToM tasks.

Standard deviations are in parentheses. *** indicates $p < .001$.

Relationship between Future Preference Task, EF and ToM Tasks

We first examined the inter-task correlations within the battery of executive function (EF) and theory of mind (ToM) tasks. All four tasks of EF (Day-Night, Knock-Tap, Spin the Pots and DCCS) were significantly correlated with each other after controlling for age (Appendix Table D.1). The five measures in the ToM task battery (Diverse Desire, Diverse Belief, Knowledge Access, False Belief Content, False Belief Location) were also significantly inter-correlated (Appendix Table D.1). Within the future preference task, after controlling for age, there were significant correlations between children's scores in the different experimental conditions of self-future trials, peer-future trials and adult-now trials (self-future and peer-future, $r = .635$, $p < .001$; self-future and adult-now, $r = .417$, $p < .001$; peer-future and adult-now, $r = .376$, $p < .001$).

Children's scores in the self-future condition and peer-future conditions were used to examine the relationship between children's reasoning of preferences changes and their EF and ToM task performance. Notably, we found significant relationships between children's performance in the **self-future** condition and several of the EF tasks, after age was controlled. Specifically, with *Day-Night* ($r = .169$, $p < .05$), *Knock-Tap* ($r = .224$, $p < .01$), *DCCS* ($r = .182$, $p < .01$), *EF composite score* ($r = .199$, $p < .01$) and *inhibition composite score* ($r = .230$, $p < .01$) (Table 3). In contrast, no EF

tasks were significantly related to children’s scores in the **peer-future** condition. Spearman’s rho correlations indicated that children’s success in the Diverse Belief task and False Belief Content task was related to performance in the **self-future** and **peer-future** conditions (Table 3). However, the significant effects disappeared when we conducted separate analysis for each age group.

Table 3. Correlations between children’s performance on the future preference task separated by test conditions, EF tasks ToM tasks.

	Self-future	Peer-future
<i>Executive Function (EF)</i>		
<i>task</i>		
EF Composite	.199**	.086
Inhibition Composite	.230**	.099
Day-Night	.169*	.042
Knock-Tap	.224**	.130
Spin Pots	-.004	.036
DCCS	.182**	.015
<i>Theory of Mind (ToM) task</i>		
Tom Composite	-.033	-.002
Diverse Desire	.095	.021
Diverse Belief	.166**	.241**
Knowledge Access	.132	.125
False Belief Content	.232**	.254**
False Belief Location	.127	.139

Note. * indicates p<.05. ** indicates p<.01, *** indicates p<.001.

Discussion

We investigated British and Chinese per-schoolers’ future-oriented reasoning, specifically the ability to understand that their future preferences would be different from the current ones for themselves and for another person. Using a within-subject design, we adapted the future preference task designed by Bélanger et al. (2014) and, for the first time, tested Chinese pre-schoolers in comparison to British pre-schoolers. Our findings replicated previous studies showing age-related performance in young children’s understanding of changes in preferences (Atance et al., 2021; Atance & Lee, 2016; Bélanger et al., 2014; Kopp et al., 2021). Our study indicated that children who were firstly asked about their current preferences outperformed those who answered questions on the future preferences first (i.e. order effect). Across age groups, children’s anticipation of the future for a peer was more accurate than their prediction for themselves (condition effect). We administered a battery

of standardized tasks of EF and ToM, and examined their underlying relationship with children's performance in the future preference task. After controlling for age, pre-schoolers' inhibition and cognitive flexibility was significantly related to the prediction of children's own future preferences, though not correlated with their prediction for another individual. Chinese children outperformed British children in the cognitive inhibition (Day-Night) and cognitive flexibility (DCCS) tasks, but there were no country differences between British and Chinese children in their performance on the future preferences task, or on working memory (Spin Pots), motor inhibition (Knock-Tap) or ToM tasks. The current study builds on the growing literature on the development of future-oriented cognition, revealing the universal developmental trajectory among Eastern and Western children, as well as the role of inhibitory control and cognitive flexibility in children's reasoning with conflicting perspectives.

With the future preference task adapted from Bélanger et al. (2014), the age effect found in the current study was consistent with previous research using the same task (Atance et al., 2021; Bélanger et al., 2014; Lee & Atance, 2016; Kopp et al., 2021), as well as studies measuring other aspects of future-oriented cognition (Atance et al., 2017; Atance & Meltzoff, 2005; Ding, Frohnwieser, Miller, Clayton, 2021; Miller et al., 2020; Russell et al., 2010; Prencipe & Zelazo, 2005; Suddendorf et al., 2011). The fact that we replicated the findings of 5-year-olds' performance being higher than the younger age groups suggests that the future preference task was an age-sensitive measure that captured the gradual developmental variability occurring during the pre-school years. Older children were increasingly more accurate in understanding that preferences would vary as a function of time (i.e. current vs future). The increased ability to predict people's changes of preferences was likely to be the combined results of several underlying cognitive abilities developing around the same time. For instance, understanding that different people have different desires and that the future lies ahead of the current moment may be the prerequisite or parallel cognition to the understanding that preference changes could occur within the same and different individual at different temporal points.

By the age of 5, children are capable of attributing different mental states as well as understanding the link and distinction between past, present and future events and emotions (Grant & Suddendorf, 2010; Lagattuta, 2014), which enable them to make more adaptive future-oriented decisions. In comparison, 3-year-olds were unable to accurately anticipate their own future preferences as reflected in their below chance level performance in the experimental-baseline condition group, echoing the original finding in Bélanger et al. (2014). Young children's difficulty with desire reasoning in imagining that another object and activity could be desirable with the extra complexity of imagining preferences for a future perspective may be particularly hard for the 3-year-olds (Cassidy et al., 2005). 3-year-old children's failure in the future preference task was unlikely to be due to their linguistic incompetency. The language comprehension ability of future tense with the

auxiliary “will” in English and the temporal adverbs indicating future in Chinese were already present in 3-year-olds (Fraser, Bellugi, & Brwon, 1963; Harner, 1981; Liang, Wu, & Li, 2019).

The effect of condition across age groups and countries in the future preference task suggests that future-oriented cognition differed as a matter of perspective that children’s performance in the peer-future trials were higher than those in the self-future trials. This finding was in line with our prediction as well as past studies adopting the same task (Bélanger et al. 2014, Lee & Atance, 2016). Notably, unlike previous research using a between-subjects design, in the current study, the comparison between the different test conditions were conducted within the same individuals, thus reducing any potential participant variations between groups and highlighting the effect of perspective taken when predicting future preferences. Although there has been growing evidence indicating overlapping cognitive processes and neural substrates underlying the reasoning about one’s own and other’s perspective (Buckner & Carroll, 2007; Hassabis & Maguire, 2007; Spreng et al., 2009), several behavioural studies have demonstrated that at least with pre-schoolers in certain scenarios, children’s future-oriented decisions were more accurate when they took the perspective of another person, usually a peer. Russell et al. (2010) revealed that only 4-year-olds, whereas not 3- or 5 years-olds, displayed the other-over-self advantage when they were asked to select tool for future use. Researchers have attributed the asymmetrical results to the 4-year-olds’ “growth error” of over applying newly developed visual perspective taking skills (Flavell, Everett, Croft, & Flavell, 1981).

One interpretation more closely related to children’s prediction of future preferences focused on the notion of “psychological distance”. Researchers have manipulated the level of social familiarity of the person who children predicted for (Lee & Atance, 2016). Setting oneself as an egocentric reference point, psychological distance involves mentally separating oneself from the immediate situation and environment, allowing greater flexibility in thoughts and actions (Trope & Liberman, 2011). Although the influence of psychological distance was less profound in pre-schoolers than in adults (Bauckham et al., 2019; Lee & Atance, 2016), children’s future-oriented reasoning was nevertheless more accurate for peers than for themselves. Likewise in the current study, we described the peer as “just like you”, e.g., same-age and same-sex, without inferring any social closeness with the children and we found evidence to support the replicated other-over-self advantage. It is possible that anticipating one’s own future preferences did not create adequate psychological distance and results in decisions being more prone to the conflicts and interference from the current perspective, in other words, egocentric bias.

Further evidence that children’s difficulty in the task could partially arise from conflicting perspectives was supported by the finding of the order effect. As a replicated finding as in Bélanger et al. (2014) and consistent with our prediction, in the current study, children who received the testing order of baseline-experimental trials, i.e. predicting current then future, outperformed those with the experimental-baseline order, i.e. predicting future then current. Similar results have been

648 reported in Atance et al. (2010) in a gift selection scenario where pre-schoolers were more likely to
649 select the age-typical and appropriate gift for their mothers if they were asked first what themselves
650 liked. Similarly, in the current study, the opportunity to identify their current preferences improved
651 children's overall performance on future prediction for the peer and themselves. Intuitively, when
652 presented with choices involving conflicting perspectives, cognitive resources could be freed up by
653 recognising, fulfilling, even the anticipation of desire fulfilment of one perspective (Atance et al.,
654 2010). In turn, this reduces the cognitive demand and facilitates the quality of decision-making for
655 another perspective. This finding has practical educational implications in guiding effective
656 parenting and pedagogical practice, such as to acknowledge children's negative emotions before
657 discussing any misconduct behaviours or inappropriate emotional reactions.

658 A particularly novel contribution of the current study was the first Eastern and Western
659 comparison in pre-schoolers' future-oriented cognition, while additionally testing for the relationship
660 between EF, ToM and future prediction ability. Our findings add to the growing cross-cultural
661 literature on children's cognitive development. The findings suggested that there was no difference
662 between British and Chinese children's performance on the future preference task, indicating a
663 universal developmental trajectory with similar age-related improvements during the preschool
664 years. Across both countries, children performed better in the peer-future trials than the self-future
665 trials, and when they identified their current desires before predicting future preferences. Taken
666 together, the conclusions drawn from our cross-cultural comparison is that the capacity to envision
667 future perspective emerges around the same time in children from different cultural environments.
668 Additionally, this ability is similarly influenced by the perspective taken for the future-oriented
669 decision as well as the extent of conflicts between multiple perspectives.

670 Broadly, the lack of cross-cultural variations was consistent with Redshaw et al.'s (2019) finding,
671 namely that there is a universal developmental trajectory among children from three cultural groups
672 (Australians living in Brisbane, Australian aboriginals, and South African Bushmen) in their ability
673 to prepare for a future event with mutually exclusive outcomes. With only two existing studies
674 focusing on different forms of future-oriented cognition, any conclusion on the universality of
675 children's ability to understand and plan for future is undoubtedly presumptuous without further
676 empirical evidence. As Atance & Jackson (2009) noted, future-oriented cognition entails different
677 scenarios and future cross-cultural studies would benefit by adopting a battery of representative tasks
678 to investigate whether there are any cultural-specific developmental patterns in other tasks
679 measuring future-oriented reasoning, such as the picture book task (Atance & Meltzoff, 2005) and
680 the blow football test (Russell et al., 2010). Furthermore, cultural variations in children's cognitive
681 development may be subtle to detect and sensitive to the type of measure. That said, a potentially
682 fruitful path for future research is to incorporate continuous measure as opposed to the widely used
683 binary outcome methods in future-oriented literature to examine whether children acquire various

684 future-oriented cognition in different steps and time (Kopp et al., 2021). For instance, the contrast in
685 ToM scaling task in Eastern and Western countries (Shahaeian et al., 2011; Wellman et al., 2006).

686 In the current study, we did find evidence of cross-cultural differences in children's EF ability.
687 Chinese pre-schoolers' performance on the cognitive inhibition and cognitive flexibility tasks were
688 higher than their British peers, a finding consistent with existing literature (Ellefson et al., 2017; Lan
689 et al., 2011; Oh & Lewis 2008; Sabbage et al., 2006; Schirmbeck et al., 2020; Xu et al., 2020). The
690 cultural differences in young children's inhibition ability are likely to reflect the consequences of
691 socialization goals. For example, parental emphasis on training children to inhibit behaviours and
692 control attention in family and educational settings in Eastern cultures (Chen et al., 1998; Eisenberg
693 et al., 2009; Liu et al., 2005). However, the Chinese children did not outperform their British
694 counterparts on measures of motor inhibition or working memory, which may be attributed to other
695 aspects of the various tasks. For example, the Knock-Tap task only involved two motor responses
696 elicited by prepotent visual stimuli. Research showing Eastern and Western contrasts on motor
697 inhibition have typically adopted more complicated tasks, such as the Head-Toes-Knees-Shoulders
698 task (Lan et al., 2011). The working memory findings were consistent with previous studies (Lan et
699 al., 2011; Sabbagh et al., 2006; Thorell et al., 2013). Anecdotally, there were cases in both countries
700 when children indicated to the experimenter in general conversation that they have played memory
701 retrieval games with similar designs previously. It is therefore possible that the prior experience with
702 task structure could have masked any subtle cross-cultural differences in working memory ability.

703 We did not find evidence of differences between Chinese children and British children on their
704 performance on the ToM tasks. Contrary to the more consistent findings of Eastern children's
705 advantage on EF, cross-cultural research on ToM have yielded mixed findings (Oh & Lewis, 2008;
706 Naito & Koyama, 2006; Wellman et al., 2006; Shahaeian et al., 2011). That said, our results still
707 echoed those of a large-scale study (Duh et al., 2016) and meta-analysis (Liu et al., 2008).
708 Specifically, children from the mainland China (like the participants in the current study) were
709 parallel to their Western peers in the overall acquisition of ToM ability. Furthermore, we did not find
710 any correlation between pre-schoolers' future preference performance and their ToM task
711 performance, which is in line with Hanson et al.'s results (2014). One possibility is that these two
712 domains of cognition develop separately during the preschool years. Although they both require
713 perspective-taking, the nature of perspective-taking differs in ToM and future-oriented scenarios.
714 The former taps into children's ability to attribute mental states in different people whereas the latter
715 requires children to reason about inter- and intra- differences between people at different temporal
716 points. Thus, their parallel developmental trajectories during the preschool years could reflect a
717 common cognitive maturation rather than two associated abilities. That said, it is possible that
718 evidence of association between ToM ability and children's prediction of the future may become
719 clearer later in the development, which is worth future exploration.

Importantly, the current study presents the first evidence to date on the relationship between children's EF competency and their understanding of preference changes. Unlike previous research using tasks with no conflicting perspectives (Hanson et al., 2014; Ford et al., 2012), the future preference task explicitly contrasted children's current and future perspective. We found that children's cognitive flexibility (DCCS task) and inhibition control (Day-Night and Knock-Tap tasks) was associated with the prediction of children's own future preferences, even after controlling for age. These findings are critical in light of the argument suggesting that difficulty of future-oriented decisions may be caused by conflicting perspectives. Children's performance partly depended on their ability to switch between contrasting perspectives and to inhibit interference from the current perspective (Buckner & Carrol, 2007; Atance et al., 2021). We measured the different aspects of children's inhibitory control, namely cognitive inhibition (Day-Night task) and motor inhibition (Knock-Tap task). In the future preference task, children can indicate their choice of items by naming it or pointing to it - we found that most children used both simultaneously. Therefore, in addition to the involvement of cognitive inhibition, in the test conditions, children need to control their motor movement to *not* point to the items which they typically like at the current moment, thus requiring motor inhibition.

There was no correlation between EF task performance and prediction of a peer's future preferences, with several possible explanations. First, EF ability has been shown to be strongly related to pre-schoolers' coordination of different perspectives in mental states ascription, particularly when children's own perspective is involved (Fizke et al., 2014). Second, in the current study, unlike Bélanger et al. (2014) we did not use any picture illustrations but relied on verbal instructions when the peer was introduced. Therefore our procedure may have resulted in children not feeling as socially close and familiar with the peer. The greater psychological distance may have contributed to the more accurate predictions in the peer-future condition (Lee & Atance, 2016). It is possible that predicting for an unfamiliar child may not require the same extent of inhibition and cognitive flexibility as for predicting for oneself or a familiar person. Future studies could test this hypothesis by investigating the prediction of a close friend or family member.

Our finding about the relationship between inhibition and future preference ability contrasted with Atance et al. (2021) who reported null results among those tasks. This may be due to scoring differences of the inhibition tasks and the standardised approach (Carlson, 2005; Carlson & Moses, 2001). Moreover, Atance et al.'s (2021) based their correlation analysis on one composite score of inhibitory control, though this composite score was created from two tasks measuring different components of EF, specifically the Sun/Moon Stroop task for inhibition and DCCS task for cognitive flexibility. Given that each EF component could support future-oriented cognition differently (Buckner & Carroll, 2007), we analysed each EF component separately, as well as using a composite score. Additionally, Atance et al. (2021) manipulated the level of conflicts in the future

756 preference task by changing the questions in the test conditions. The study included control
757 questions to reduce children's bias in answering yes/no type questions. However, these control
758 questions nevertheless targeted on children's semantic knowledge (whether fish have legs) and did
759 not resemble the test questions in the future preference task that involved the understanding of
760 mental states.

761 There was no relationship between children's performance on the working memory task and the
762 future preference task. This finding could arise from a protocol feature that in the future preference
763 task children were reminded over each trial to make future-oriented decisions, which may have
764 minimised the involvement of working memory. We suggest that the link between being able to
765 mentally store and manipulate information, and to understand and plan for the future is mostly
766 highlighted in scenarios when there is a need to consider the future perspective over a period of time.
767 For example, in the prospective memory task (Ford et al., 2012) and in the future planning task of
768 tool use (Ünal and Hohenberger, 2017).

769 The cross-cultural comparison of children's performance in the future preference task was of
770 particular theoretical interest to the research on the cognitive correlates of future-oriented cognition.
771 Our results show that there were significant relationships between children's ability to predict their
772 own future preferences and their performance in the inhibition and cognitive flexibility task.
773 However, the Chinese children's advantage on the executive function skills did not lead to them
774 outperforming their British counterparts in the future preference task. It suggests that inhibition and
775 cognitive flexibility may well be one of the several scaffolding abilities that support children's
776 reasoning with conflicting perspectives. Therefore, the possibility remains that children's future-
777 oriented reasoning is related to other cognitive abilities that we haven't tested, suggesting a
778 potentially promising direction for future research.

779 To summarize our findings, we present the first East versus West comparison of pre-schoolers'
780 future-oriented cognition, assessing their ability to understand changes of preferences occurring
781 within oneself and within another individual, and related these findings to EF and ToM task
782 performance. In accordance with previous studies, we found age-related changes in performance
783 within British and Chinese children, indicating a possible universal developmental trajectory. We
784 also found that Children's prediction of future preferences was improved when they had the
785 opportunity to identify their current preferences before anticipating the future. Interestingly,
786 children's prediction for peers was more accurate than their predictions for themselves, perhaps due
787 to the fact that children's prediction of their own future preferences (though not of others) was
788 significantly related to their inhibition and cognitive flexibility abilities. Chinese children
789 outperformed their British counterparts on the cognitive inhibition and cognitive flexibility tasks, but
790 there were no country-related differences in motor inhibition, working memory, ToM or the future
791 preference task, suggesting other cognitive abilities may play a role in the process of future-oriented

reasoning. Taken together, the results of our current study paves the way for future research on the cognitive correlates and underlying mechanisms of future-oriented cognition. It advocates for a diverse and integrated approach to investigate cognitive development in children with regards to cross-cultural research.

Authors' contributions

N.D. R.M., and N.S.C conceived and designed the experiments. N.D. ran the experiments and R.M and N.D analysed the data. N.D prepared the manuscript, which was reviewed, discussed and edited by R.M. and N.S.C.

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Appendices

Appendix A

Protocols for the executive function (EF) and theory of mind (ToM) tasks

Executive Function Tasks

Knock-Tap Task (Luria, 1966): This motor inhibition task taps into children's ability to inhibit established motor movement and prepotent responses evoked by visual stimuli. In the first part of the study, children were asked to mimic the experimenter's hand movement. After passing 8 consecutive trials, children were asked to perform the opposite hand movement from the experimenter. Specifically, to tap on the table with an open palm when the experimenter knocks on the table with a

828 fist, and vice versa. The motor inhibition score was recorded as the total number of correct trials out
829 of 15 trials.

830

831 *Day-Night Task (Gerstadt, Young, Diamond, 1994)*: This task is a classic stroop-like verbal
832 cognitive inhibition task. The experimenter firstly showed the child the “day” card (picture of the
833 sun) and the “night” card (picture of the moon) and they were asked to identify the objects on the
834 cards. The experimenter then explained the rules and children were instructed to say “day” for the
835 night card and “night” for the day card. A total of 16 cards were shown one at a time in a random
836 order. There were 2 practical trials with one trial of each picture card to ensure that the children
837 understand the rules. If they failed, the experimenter would repeat the instructions followed by 2
838 additional practice trials. Accuracy out of 16 trials were recorded.

839

840 *Dimensional Change Card Sort Task (DCCS)*: This task measured cognitive flexibility and children
841 were asked to sort 12 cards in two sets based on a rule of colour or shape of the pictures. After the
842 first set of six cards, the rule switched and children were required to sort the second set of cards by a
843 different rule. The order of sorting rule was counterbalanced; half the children started with colour
844 and switched to shape whereas the other half started with shape and switched to colour. The number
845 of correct responses in the post-switch phase (out of 6 trials) was recorded.

846

847 *Spin the Pots Task (Hughes & Ensor, 2005)*: This task assessed children’s working memory. The
848 experimenter first introduced 8 visually distinct pots differing in colour and placed them on a lazy
849 Susan rotating tray. Children were shown that there were 6 stickers, each was hidden under one pot
850 with two pots remaining empty. The experimenter then covered the whole display with a cloth and
851 spun it around and children were asked to retrieve the stickers one by one. In each trial, children
852 must choose one pot after the spinning has stopped and cloth removed. The task ended when all six
853 stickers have been found or the children have reached a maximum of 12 attempts. Children’s
854 working memory was calculated as 12 minus the number of errors made.

855

856 Theory of Mind Tasks

857 *Diverse Desire (Wellman & Liu 2004)*: The experimenter first introduced a toy figure “Mr Bear” and
858 children were shown a picture of orange juice and a picture of milk. They then answered a question
859 of their own desire “which drink do you like best, orange juice or milk?”. Whichever drink the
860 children chose, the experimenter told the children “Mr Bear doesn’t like [drink the child chose] and
861 Mr Bear really likes [other drink]. Mr Bear is thirsty, which drink will Mr Bear choose?”. The order
862 in which the drinks were named was counterbalanced and children received a score of 1 if they

863 correctly responded to the question with the opposite drink from their own desire (total score range:
864 0-1).

865

866 *Diverse Belief (Wellman & Liu 2004)*: Children were shown a toy figure and pictures of a bed and a
867 basket. The experimenter said “Here is Thomas and he wants to find his bunny. His bunny might be
868 hiding under the bed or it might be hiding in the basket.” The children were then asked “Where do
869 you think Thomas’s bunny is hiding, under the bed or in the basket?”. Whichever location the
870 children chose, the experimenter told them that Thomas thinks the bunny is hiding in the opposite
871 location and asked the target question: “So where will Thomas look for his bunny, in the basket or
872 under the bed?” The order in which the locations were named was counterbalanced and children
873 received a score of 1 if they answered correctly to the target question with the opposite location
874 given to their own belief (total score range: 0-1).

875

876 *Knowledge Access (Pratt & Bryant, 1990)*: Children were shown a miniature wooden box
877 containing a small plastic toy. The experimenter asked the children: “what do you think is inside the
878 box” (the child could give any answer they like or say I don’t know). Next, children were invited to
879 open the box and see what was inside and play with it. The experimenter then closed the box and
880 asked: “Okay, what is in the box?” A toy figure named “Polly” was introduced and the experimenter
881 asked children the target question: “Polly has never ever seen inside the box. Now comes Polly. So,
882 does Polly know what is in the box?”, followed by a memory question: “Did Polly see inside the
883 drawer?”. Children need to correctly answer both the target and memory questions to be given a
884 score of 1 (total score range 0-1).

885

886 *False Belief Content (Flavell, Green & Flavell, 1989)*: The experimenter showed the children a
887 closed egg box with a label and a clear image of chicken eggs on the surface, however box contained
888 bouncy balls instead. After asking the children: “What’s inside the box?”, the experimenter opened
889 the box, revealed the bouncy balls and encouraged them to play with the toys. Next, the box was
890 closed with the bouncy balls inside, and the experimenter asked the representational change
891 question: “Before you looked inside, what did you think was inside the box?”, followed by the
892 reality control question “what’s in the box really?”. The children were then asked the false belief
893 question: “your friend hasn’t seen what’s inside this box, if they see this box all closed up, what will
894 they think is inside it, eggs or balls?”. To receive a score of 1, children need to correctly answer all
895 three questions (a neutral term “think” was used, “yi3 wei2” was used for the Chinese participants)
896 (total score range 0-1).

897

898 *False Belief Change of Location (Baron-Cohen, Leslie & Frith, 1985)*: Children were told a story
899 that was demonstrated by the experimenter with two playmobile characters (“Su” and “Shaun”), a
900 little box, a basket with a blanket and a little ball. Shaun first played with the little ball and put the
901 ball in the box before going play outside. Su entered the room and took out the ball from the box to
902 play then put it in the basket and covered it with cloth, then went outside. At this point, the children
903 were asked three forced-choice control questions to assess their memory of the story. If the children
904 failed to answer all three questions correctly, the experimenter would repeat the process to ensure
905 that they understand the story. The task would terminate after the children’s failure to pass the
906 memory control questions after the second attempt. Next, the experimenter continued the task by
907 saying that Shaun has returned to the room and he wanted to play with the ball. Children were then
908 asked the false belief prediction question: “Where will Shaun look for his ball?” (A neutral term
909 “look” was used, “zhao 3” for the Chinese participants). The experimenter then demonstrated that
910 Shaun went to the box and opened it, but it was empty. Lastly, the children were asked the false
911 belief explanation question: “why did Shuan look for his ball in the box?”. A score of 1 was given if
912 the children correctly responded to both the false belief prediction and false belief explanation
913 question (total score range 0-1).

14 Appendix B

15

16 B.1. List of item pairings in the UK and China.

Category	UK		China	
	child-preferable	adult-preferable	child-preferable	adult-preferable
Drink-Snack	Ribena fruit juice Percy & Penny biscuit carton theme smoothie fruit flavour gums sweets Animal theme yoghurts	Twining Tea whole grain flatbread coffee whole nuts olives wine	cartoon theme juice animal theme cookie cartoon theme milk marshmallow Lollipop Animal theme yoghurts	Chinese green tea ginger flavour cracker coffee roasted pumpkin seeds hotstrip gluten food beer
Reading-Watching	picture book crayons Peppa Pig Bing cartoon	newspaper fountain pen cooking shows gardening shows documentary	picture book crayons Peppa Pig Paw Patrol cartoon	newspaper fountain pen cooking shows National Treasure documentary
Leisure-Game	sticker book animal puzzle watching cartoon colouring	travel magazine crossword puzzle going to concert poker games	sticker book character puzzle watching cartoon colouring	travel magazine Mahjong going to concert poker games

17

918 Appendix C

919

920 Children’s performance in the future preferences task

921

922 Across all trials (i.e. both test and baseline trials), the full model differed significantly from the null

923 model ($X^2 = 428.39$, $df = 6$, $p = <0.001$). We found main effects of **age in years**, **condition**, **order**

924 and **trial type** on success rate, with no main effects of country, sex or trial number (S1 Table).

925

Fixed term	Estimate	z-value	p-value
Age in years	0.879	8.011	< 0.001
Condition	0.701	4.874	< 0.001
Order	-0.426	-3.704	< 0.001
Trial type	-3.239	-17.634	< 0.001
Country	-0.155	-1.732	0.083
Sex	0.102	0.917	0.359
Trial number	0.024	0.849	0.396

926 C.1. Generalized linear mixed models on factors affecting success rate (test and baseline trials) in

927 future preference task in children (n = 182). P-values <0.05 are highlighted in bold.

28 Appendix D

29

30 D.1. Correlations between executive function (EF) and theory of mind (ToM) tasks.

Task	2	3	4	5	6	7	8	9	10	11	12
1. EF Composite	.900***	.782***	.742***	.661***	.554***	.026	.227**	.247**	.491**	.539**	.403**
2. Inhibition Composite	-	.862***	.833***	.326**	.354***	-.007	.198**	.217**	.414**	.446**	.322**
3. Day-Night		-	.438***	.286**	.329***	.031	.194**	.206**	.438***	.401***	.303***
4. Knock-Tap			-	.266**	.268**	-.046	.146**	.168**	.263***	.384***	.267**
5. Spin the Pots				-	.244**	.065	.163**	.185**	.371**	.409**	.319**
6. DCCS					-	.030	.185**	.134**	.458***	.513***	.389***
7. ToM Composite						-	.460**	.598***	.782***	.827***	.848***
8. Diverse Desire							-	.374***	.363***	.223***	.295***
9. Diverse Belief								-	.407***	.298***	.342***
10. Knowledge Access									-	.476***	.563***
11. False Belief Content										-	.665***
12. False Belief Location											-

31 Note. * indicates $p < .05$. ** indicates $p < .01$, *** indicates $p < .001$.

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