Children Use Probability to Infer Other People's Happiness

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Abstract

The ability to infer other people's emotions is an important aspect of children's social cognition. Here, we examined whether 4- to 6-year-olds use probability to infer other people's happiness. Children saw a scenario where a girl receives two desired and two undesired gumballs from a gumball machine and were asked to rate how the girl feels about this outcome. Children either saw the gumballs come from a machine that had mostly desired gumballs or a machine that had mostly undesired gumballs. Five- and 6-year-olds rated the girl as being happier when the gumballs came from a machine that had mostly undesired gumballs. Four-year-olds, on the other hand, rated the girl's happiness similarly regardless of whether the machine held mostly desired or undesired gumballs. These findings show that by the age of 5, children use probability to infer happiness. Further, they demonstrate that children understand that our happiness with an outcome depends on whether a better or worse outcome was initially more likely.

Keywords: emotion attribution; happiness; probability; social cognition; cognitive development

Introduction

Successful social interactions require the ability to infer whether others are happy or sad. Inferring these emotions helps us explain people's past behaviors, predict their future actions, and lets us know how we should behave towards them. For example, knowing whether someone is in a positive or negative mood can help us decide whether it is a good time to ask them for a favor. These abilities are especially important during childhood as difficulties in emotion attribution could significantly disrupt social interactions and interfere with children's ability to form friendships.

Children sometimes infer happiness by relying on memorized scripts (e.g., Barden, Zelko, Duncan, & Masters, 1980; Harris, Olthof, Terwogt, & Hardman, 1987; Russell, 1990; Widen & Russell, 2010, 2011). For example, children can remember specific antecedents and consequences of happiness, and use these to infer happiness in the future (e.g., people are happy when they eat cake). Children also infer happiness by considering others' desires and goals (e.g., Hadwin & Perner, 1991; Skerry & Spelke, 2014; Wellman & Bartsch, 1988; Wellman, Phillips, & Rodriguez, 2000; Wellman & Woolley, 1990). For example, young children understand that a boy will be happy if his desires are fulfilled, but will be sad if his desires are unfulfilled (Wellman & Woolley, 1990). Even preverbal infants understand that an achieved goal should elicit positive emotions and a failed goal should elicit negative emotions (Spelke & Skerry, 2014).

However, a more sophisticated understanding of happiness requires recognizing that people's happiness can depend on their expectations. Beliefs are one type of expectation. Children, like adults, understand that people's happiness can depend on their beliefs (e.g., Bradmetz & Schneider, 1999 Experiment 3; Harris, Johnson, Hutton, Andrews, & Cooke, 1989; Nguyen & Frye, 1999 Experiment 2; Ong, Asaba, & Gweon, 2016). For example, in one study, 4- to 5-year-olds, and adults saw scenarios where two characters were bowling (Ong et al., 2016). One character believed she would get a gutter ball and the other character believed she would get a strike, based on the trajectory of the ball midway down the lane. Both characters ended up knocking down three pins. Four-year-olds rated both characters as being similarly happy. However, 5-year-olds, like adults, reported more happiness for the character who believed she would get a gutter ball. This suggests that by age 5, children understand that people's happiness about identical outcomes can vary depending on their beliefs.

Expectations can also be instantiated in terms of *probability*. We expect highly probable events to occur, but do not expect highly improbable events to occur. Further, probability can shape how we feel about identical outcomes – a positive outcome feels better when it is unlikely to occur compared to when it is likely, and similarly, a negative outcome feels worse when it is unlikely to occur compared to when it is likely (e.g., Mellers, Schwartz, Ho, & Ritov, 1997; Shepperd & McNulty, 2002). For example, in a gambling task, adults were more elated with a win when their chances of winning were lower compared to higher, and were more disappointed with a loss when their chances of losing were lower compared to higher (Mellers et al., 1997). This demonstrates that probability plays an important role in adults' attributions of happiness.

Although no research has yet examined whether children use probability to infer happiness, we recently found that children use probability to infer surprise (Doan, Friedman, & Denison, in press). By the age of 7, children understand that people will be more surprised by an outcome if the likelihood of that outcome is low compared to high. Further, 6-year-olds' surprise judgments improve when they are prompted to consider probabilities, but not when they are prompted to consider people's beliefs. Thus, it is possible that children use probability to also infer happiness.

To investigate whether children use probability to infer people's happiness, we showed 4- to 6-year-olds a scenario where a girl stood either before a gumball machine that contained mostly "yummy" red gumballs and few "yucky" black gumballs, or a machine that contained the reverse distribution. In both conditions, the girl wanted red gumballs, and the machine dispensed 2 red and 2 black gumballs. Children were asked to rate how the girl felt about getting these gumballs using a 7-point scale ranging from extremely sad to extremely happy. If children consider probability when predicting happiness, they should rate the girl as happier when the machine has mostly black gumballs.

Method

Participants

One hundred and eighty children were tested: 60 4-year-olds (M = 4;6 [years; months]; range = 4;0 – 4;11; 29 girls), 60 5-year-olds (M = 5;5; range = 5;0 – 5;11; 26 girls), and 60 6-year-olds (M = 6;5; range = 6;0 – 6;11; 34 girls). All children were individually tested at schools and daycares in a mid-sized Canadian city in Southwestern Ontario.

Materials and Procedure

All materials were shown on a laptop computer. Children were told a story about a gumball machine containing red and black gumballs. Children were told that the red gumballs are yummy and the black gumballs are yucky. A girl then appeared beside the gumball machine. Children were told that she wants a red gumball, and were asked a comprehension check question to confirm that they understood. The girl then pulled the handle of the machine, and ended up getting two red and two black gumballs. Children were next asked to rate how the girl feels using a 7-point happy face scale, ranging from extremely sad to extremely happy.

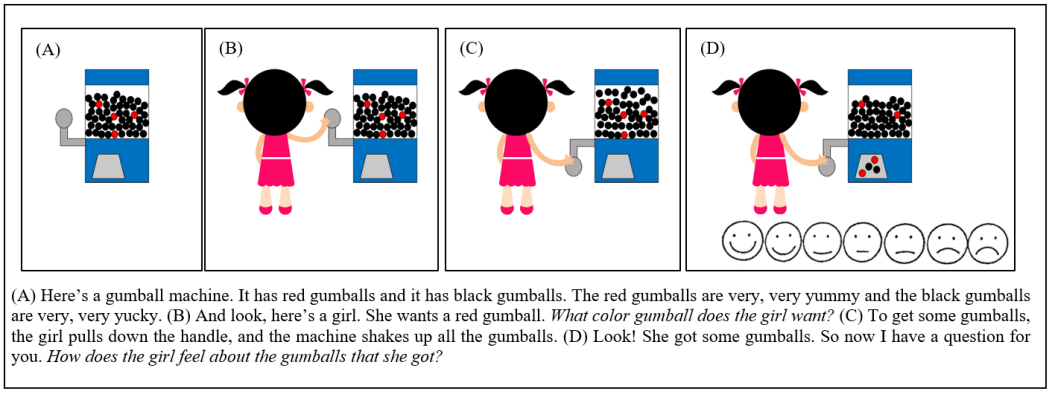
Children were randomly assigned to see this story in one of two between-subjects conditions. In the Mostly Yummy condition, the gumball machine contained many red gumballs and just a few black gumballs (46 red; 4 black). In the Mostly Yucky condition, the gumball machine contained many black gumballs and just a few red gumballs (46 black; 4 red). See Figure 1 for a sample of the story and script for the Mostly Yucky condition.

Results

Of interest was whether children are able to use probability to infer the girl's happiness. More specifically, we wanted to see if children's happiness ratings for the girl would differ depending on the distribution of gumballs. Figure 2 shows the mean scores for children's happiness ratings.

A 2 (condition: Mostly Yummy, Mostly Yucky) x 3 (age: 4, 5, 6) ANOVA revealed a marginal effect of condition, $F(1,174) = 3.40$, $p = .067$, $\eta^2p = .019$, and no effect of age, $F(2,174) = 2.09$, $p = .127$. There was a significant age by condition interaction, $F(2,174) = 4.39$, $p = .014$, $\eta^2p = .048$. We explored each age group separately and found that 6-year-olds rated the girl as being significantly happier in the Mostly Yucky condition ($M = 2.13$, $SD = 1.38$) than in the Mostly Yummy condition ($M = 0.83$, $SD = 1.86$), $F(1,58) = 9.45$, $p = .003$. Five-year-olds also rated the girl as being significantly happier in the Mostly Yucky condition ($M = 1.63$, $SD = 1.88$) than in the Mostly Yummy condition ($M = 0.47$, $SD = 2.45$), $F(1,58) = 4.28$, $p = .043$. However, 4-year-olds did not show differences between the two conditions, $F(1,58) = 1.39$, $p = .243$.

We also explored each condition separately and found that children's ratings in the Mostly Yucky condition differed by age, $F(2,87) = 6.65$, $p = .002$, but their ratings in the Mostly Yummy condition did not differ by age, $F(2,87) = 0.56$, $p = .576$. In the Mostly Yucky condition, 5- and 6-



(A) Here's a gumball machine. It has red gumballs and it has black gumballs. The red gumballs are very, very yummy and the black gumballs are very, very yucky. (B) And look, here's a girl. She wants a red gumball. *What color gumball does the girl want?* (C) To get some gumballs, the girl pulls down the handle, and the machine shakes up all the gumballs. (D) Look! She got some gumballs. So now I have a question for you. *How does the girl feel about the gumballs that she got?*

Figure 1: Sample slides and script for the Mostly Yucky condition.

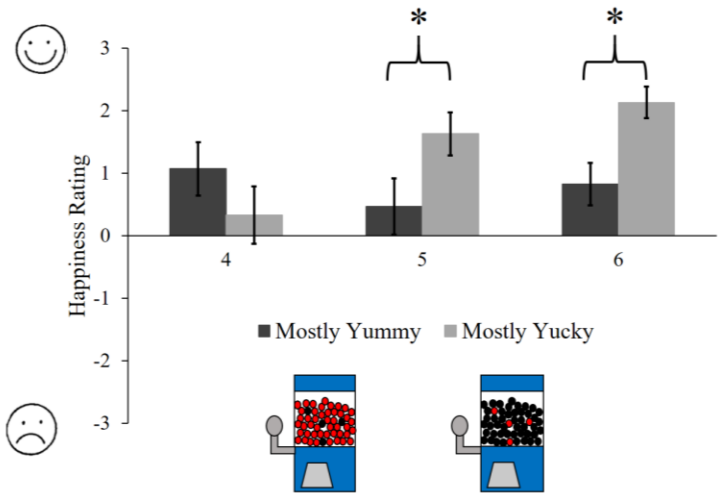


Figure 2: Mean scores for children's happiness ratings, with -3 being extremely sad, and 3 being extremely happy. Error bars show ± 1 standard error of the mean.

year-olds rated the girl as being happier than 4-year-olds did, $t(58) = 2.28$, $p = .006$, and, $t(58) = 3.46$, $p < .001$, respectively. Six-year-olds in the Mostly Yucky condition also rated the girl as being happier than 5-year-olds did, $t(58) = 1.17$, $p = .032$.

Discussion

In this study, we explored whether 4- to 6-year-old children use probability to infer other people's happiness. We showed children either a scenario where a girl had a high chance of receiving the desired gumballs, or a scenario where a girl had a low chance of receiving them. In both conditions, the girl received two desired and two undesired gumballs. Children were asked to rate the girl's happiness with this outcome. We found that by the age of 5, children rated the girl as happier when she had a lower chance of receiving desirable gumballs. This demonstrates that 5-year-olds understand that people's happiness depends on their expectations. More specifically, they demonstrate that happiness with an outcome depends on whether a better or worse outcome was initially more likely.

This study provides the first evidence that children use probability to infer people's happiness. The findings show that children do not only infer happiness by relying on memorized scripts (e.g., Barden et al., 1980; Harris et al., 1987; Russell, 1990; Widen & Russell, 2010, 2011). If children in our study inferred happiness by relying on scripts, they should have rated the girl similarly in both conditions. For example, if children were using a script, such as, "People are happy when they get (yummy) candy", then they should have rated the girl as being similar in happiness in both conditions because the outcomes were identical. Further, our data shows that children do not only infer happiness by considering others' desires and goals (e.g., Hadwin & Perner, 1991; Skerry & Spelke, 2014; Wellman & Bartsch, 1988; Wellman et al., 2000; Wellman & Woolley, 1990). In both conditions of our study, the girl wanted the red gumballs, so if children only considered her desires, then again, they should have rated the girl's happiness in both conditions similarly because she obtained what she wanted in both conditions. Thus, the happiness differences we find between conditions with 5- and 6-year-olds can only be explained by children considering the girl's chances of receiving the desired gumballs.

It is puzzling that 4-year-olds did not show differences across the two conditions. By this age, children are sensitive to probability information. For example, in violation of expectation paradigms, infants look longer at improbable outcomes than at probable ones (Denison, Reed, & Xu, 2013; Téglás, Girotto, Gonzalez, & Bonatti, 2007; Xu & Garcia, 2008). Further, children expect the majority item in a distribution to be sampled most often (e.g., Denison et al., 2013; Denison, Konopczynski, Garcia, & Xu, 2006; Girotto, Fontanari, Gonzalez, Vallortigara, & Blaye, 2016), and use probability in social inferences, such as when inferring another person's preferences (Kushnir, Xu, & Wellman, 2010; Ma & Xu, 2011). Thus, it is unlikely that our pattern of data can be explained by 4-year-olds not understanding probability. It is also unlikely that 4-year-olds' difficulty stemmed from an inability to use our happiness scale, as preschoolers have successfully used similar scales in other research (e.g., Gautam, Bulley, von Hippel, & Suddendorf, 2017; Kopp, Atance, & Pearce, 2017; Ong et al., 2016).

A more likely explanation for the younger children's insensitivity to our manipulation is that they do not spontaneously consider probability when making happiness judgments. In fact, young children may not spontaneously consider expectations in general. In Ong et al. (2016), 4-year-olds rated a girl who believed she would get a strike and a girl who believed she would get a gutter ball as being similarly happy with knocking down three pins. This suggests that they were not able to consider the girls'

expectations of knocking down pins when inferring her happiness. However, when they were given explicit information about the girls' expectations (e.g., "Sally thinks that her ball is going to go out and hit none of the pins!" for the girl who expected to get a gutter ball), 4-year-olds were able to adjust their happiness ratings. Further, in a recent study, we found that 6-year-olds improved in their surprise judgments when they were prompted to consider probability, compared to when they answered other kinds of prompt questions (Doan et al., in press). These findings suggest that children are able to use expectations to infer emotions if they are made aware of the expectation, but may have difficulties doing so spontaneously.

In a future study, we could explicitly tell children about the girl's expectations or prompt them to consider her expectations to see if this changes their happiness ratings. Because expectations can be instantiated in terms of beliefs (e.g., Bradmetz & Schneider, 1999 Experiment 3; Ong et al., 2016), or probabilities (e.g., Mellers et al., 1997; Shepperd & McNulty, 2002), we can prompt children to consider either the girl's beliefs or the girl's chances of getting the desired (or undesired) gumballs to see whether one, or both types of expectations can change their happiness judgments. If prompting children to consider the girl's chances of getting the desired gumballs improves children's happiness judgments, this suggests that their difficulty to differentiate the girl's happiness between our two conditions stems from an inability to spontaneously use expectations to infer happiness, and not an inability to see the connection between probability and happiness.

Conclusion

Probability influences how we feel. Here, we find that even children understand that the same outcome can elicit different degrees of happiness, depending on whether a better or worse outcome was initially more likely. More specifically, they understand that having a lower chance of receiving something desirable makes people happier when they do get it. Our findings are the first to demonstrate that children consider probability when inferring other people's happiness. This research extends our knowledge of the social importance of probability, and increase our understanding of the ways in which children attribute emotions.

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