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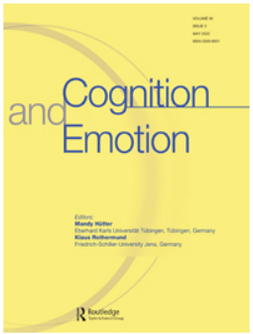

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BRIEF REPORT

Infants use emotion to infer intentionality from non-random sampling events

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ABSTRACT

Infants use statistical information in their environment, as well as others' emotional communication, to understand the intentions of social partners. However, rarely do researchers consider these two sources of social information in tandem. This study assessed 2-year-olds' attributions of intentionality from non-random sampling events and subsequent discrete emotion reactions. Infants observed an experimenter remove five objects from either the non-random minority (18%) or random majority (82%) of a sample and express either joy, disgust, or sadness after each selection. Two-year-olds inferred the experimenter's intentionality by giving her the object that she had previously selected when she expressed joy or disgust after non-random sampling events, but not when she expressed sadness or sampled at random. These findings demonstrate that infants use both statistical regularities and discrete emotion communication to infer an agent's intentions. In particular, the present findings show that 2-year-olds infer that an agent can intentionally select a preferred *or* an undesired object from a sample as a function of the discrete emotion. Implications for the development of inferring intentionality from statistical sampling events and discrete emotion communication are discussed.

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statistical inference; emotion; intentionality; infancy

Statistical inferences and emotional communication guide our interpretation of social intentions. For instance, seeing a woman open a bag of trail mix and select out all the raisins one at a time might lead one to assume that she prefers raisins. However, that assumption would change if you saw her preform the same act but express disgust after each raisin selection before continuing to enjoy the now raisin-less bag. These contrasting examples are plausible everyday scenarios of intentional selections that underscore the role of emotion when attributing preferences from non-random sampling events. Specifically, while it is expected that individuals act intentionally toward preferred objects (Woodward, 1998), it is also the case that agents can intentionally select undesirable objects out of a sample to achieve their goals, such as when someone cleans out the fridge, separates recycling from trash, or disposes of unwanted raisins from trail mix. Here, we investigated whether 2-year-old infants use an agent's emotional communication (i.e. joy, disgust, sadness) to infer her intentionality from non-random sampling selections.

Cues for inferring intentionality

Consistency and efficiency. Humans have a penchant for taking an intentional stance (Dennett, 1989). Even young infants expect agents to act intentionality towards their goals through the principle of rationality – agents will act consistently and efficiently in relation to their goals, desires, and beliefs (Baillargeon et al., 2016). For instance, 6-month-old infants expect that a consistently repeated object selection is intentional and indicates a preference for that object (Woodward, 1998) and that agents will use the most

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efficient means to reach their goal (Liu & Spelke, 2017). Moreover, when the principles of consistency and efficiency are pitted against one another, 16-month-old infants infer that agents have a preference for an object when they act consistently, yet in an inefficient manner towards that object (Scott & Baillargeon, 2013). For example, although it may have been most efficient to take whichever piece of trail mix that was at the top of the bag, the fact that the woman consistently chose raisins despite it being a less efficient action showcased her goal to obtain the raisins.

Statistical Regularity and Probability. Our detection of patterns in the environment stems from the human tendency to learn from statistical information. In addition to using statistical regularities to learn words, physical reasoning, and causal relationships (Saffran & Kirkham, 2018), infants also learn about the desires and beliefs of agents from such information (Wellman et al., 2016). In a noteworthy study, Kushnir et al. (2010) found that 20-month-olds inferred agent preferences from non-random sampling events. In this study, infants saw an experimenter select five toys from a sample containing a majority (82% present) of toy ducks and a minority (18% present) of toy frogs. Then infants were instructed to offer either toy to the experimenter in test. Infants offered the toy that the agent had previously selected more often when she consistently selected minority (18% present) toy frogs five times out of the sample than when she consistently selected the majority (82% present) toy ducks. Thus, infants inferred intentionality from the agent's selection of the minority frogs due to its consistent, yet inefficient, nature, whereas her selection of the majority ducks offered little information regarding intentionality because the selection could be expected by chance. This research indicates that infants can make inferences about intentionality based on sampling probabilities.

Emotional Communication. The role of discrete emotions in attributing intentionality from non-random sampling events has not been studied. In fact, Kushnir et al. (2010) controlled for affect by having the agent only express joy after making her selections. However, emotions differing in valence (i.e. positive vs. negative) and arousal (i.e. excitability) communicate distinct goals and intentions of agents (Reschke et al., 2017a). Indeed, infants can distinguish between emotions differing in valance and arousal (e.g. joy and anger) in the first year of life (Flom & Bahrick, 2007) and can discriminate between emotions of the same valence with similar arousal levels (e.g. anger and disgust) in the second year of life (Ruba et al., 2017). Beyond discrimination, infants also link discrete emotions to agents' goals, intentions, and actions. For instance, 12-month-old infants expect joy and sadness to correspond to agents' goal achievement and goal failure, respectively (Reschke et al., 2017b), and 18-month-old infants can use an agent's expression of frustration to infer their intentions to complete an unfinished action (Reschke et al., 2020). Infants also link emotions with actions; 14-month-old infants expect an agent to perform actions that correspond to their anger or joy expression (Hepach & Westermann, 2013), and 18-month-old infants provide more help in emotional situations to agents who express sadness in appropriate circumstances (Chiarella & Poulin-Dubois, 2018). Therefore, discrete positive and negative emotions communicate distinct intentions, goals, and actions of agents. With regards to disgust, while infants associate disgust with object avoidance (Rottman, 2014), it is not known whether infants also link disgust to intentional avoidant actions, such as the woman selectively ridding the raisins from her snack.

Current study

This investigation examined 2-year-olds' use of discrete emotion communication to infer an agent's intentionality from statistical sampling events. Specifically, we manipulated the discrete emotion (i.e. joy, disgust, sadness) an agent expressed following her selection of either the majority (random sampling) or minority (non-random sampling) object. The study had 3 predictions. First, we predicted infants in the joy trials would infer the agent's preference by giving her the target object (i.e. the object type she previously selected) more often in the non-random minority (18%) sampling condition compared to the random majority (82%) sampling condition, replicating the findings from Kushnir et al. (2010). Second, we predicted a similar pattern of results would emerge in the disgust trials: infants would give the target object more often in disgust trials in the minority (18%) sampling condition than in the majority (82%) sampling condition, to help decontaminate the sample. Although disgust functions to prompt avoidance of aversive foods and pathogens, it can also motivate the intentional removal of contaminated objects (Rozin & Fallon, 1987) – a concept

understood in infancy (Brown & Harris, 2012). Therefore, disgust may communicate general avoidance in the random majority (82%) condition but may communicate intentionality when combined with non-random minority (18%) statistical sampling information. Conversely, our third prediction was that sadness, which infants understand is typically elicited by goal failure (Reschke et al., 2017b), would be an irrational response to the agent consistently picking the non-random (18%) minority object from the sample when she could have more easily picked the random (82%) majority object to achieve her goal. Thus, infants in this condition were expected to give the objects at chance in the minority (18%) condition.

Examples of the emotional expressions, stimuli, and data analyzed in the study is accessible as supplementary materials (https://osf.io/zk3a5/).

Method

Participants

Forty-eight 2-year-olds ($M = 27.57$ months, $SD = 3.14$, range = 23-31) participated in the study. A power analysis based on Kushnir et al. (2010) determined that 48 infants were needed to detect an effect size of 0.60 between conditions. Twenty-four infants (14 female) were assigned to the non-random minority (18%) sampling condition and 24 (13 female) were assigned to the random majority (82%) sampling condition. No differences across conditions were present for infant age, $t(46) = -0.79$, $p = .43$, or gender distribution, X^2 (1, 47) = 0.09, $p = .77$. Most parents had a high school ($n = 17$) or college degree ($n = 15$), and the average household income was $50,000 ($SD =$ $40,000). An additional 15 infants were excluded from the study: 10 based on criteria (from Kushnir et al., 2010) of needing to offer at least 1 toy to the experimenter in test over all trials (excluded infants were evenly distributed across conditions: majority sampling condition = 6; minority sampling condition = 4), 2 because the experimenter's emotion expressions were deemed unacceptable, and 3 due to fussiness. All participants were recruited from the California San Joaquin Valley.

Materials

Three sets of small bath toys were contained in clear plastic boxes (length = 10 7/8 in., width = 7 1/2 in., height = 6 3/8 in). Each set had a 31:7 ratio of ducks and frogs, fish and whales, or dolphins and crocodiles. The proportion of each toy type and presentation order of the toy sets were both counterbalanced. Each set also had a corresponding smaller box (length = 10 3/4 in., width = 6 7/8 in., height = 2 3/4 in) that contained 5 of each toy type from the larger set. The use of a single smaller container (as opposed to two containers in Kushnir et al., 2010) afforded infants the opportunity to decontaminate the sample, as was predicted in disgust trials.

Procedure

All procedures were approved by the University of California Merced Institutional Review Board: UCM2016-94. The procedures mirrored those used in Study 2 of Kushnir et al. (2010), with minor adjustments to allow multiple trials with varying emotion expressions. Infants were seated on their parent's lap at a table. Experimenter 1 (E1) stood on the opposite side of the table. Experimenter 2 (E2) stood behind a room dividing curtain out of sight of the infant, which made her blind to the selection condition but still able to hear. A warm-up phase consisted of a turn-taking game to allow infants to become comfortable sharing with the E1. The infant and E1 took turns passing back and forth a toy car, toy dinosaur, and toy horse. The first trial began after all toys had been successfully passed back to the E1.

After receiving the final warm-up toy, E1 stepped behind the curtain and out of sight from the infant. Then, E2 entered, set the first box of toys on the table, and took out one toy at a time from the box, labelled it, and let the infant handle it for a few seconds before asking for it back. After the infant handled and returned both toy types, E2 returned to behind the curtain, and E1 reemerged across the table from the infant.

E1 then proceeded to take out 5 toys of the same type (e.g. all frogs) from the box, one at a time. The standing position of E1 allowed her to express each emotion through her face, voice, and posture upon each selection while alternating her gaze between the toy and the infant. The emotion expressions were communicated as follows:

Joy. E1 raised her eyebrows, widened her eyes, and smiled with her teeth showing while maintaining an upright posture with a whole hand grip on her selected toy. She said in a high-pitched excited tone of voice, "Wow, I got a [frog]."

Disgust. E1 furrowed her brow, scrunched her nose, and curled her lip up while moving her head, but not torso, away from the toy she selected and held with a pincer grip. She said in an elongated tone with rough intonations, "Ew, yuck, I got a [frog]."

Sadness. E1 raised the interior of her eyebrows, had downward eyes, and pouted her lips while slouching her shoulders and holding the selected toy with a limp wrist. She said in a low, slightly whiny, tone, "Oh no, I got a [frog]."

After making all five selections, E1 left by going behind the curtain. Next, E2 came back out, removed the toy box by putting it behind the curtain, and placed the smaller box on the table out of the reach of the infant and left. Then, E1 returned, pushed the smaller box towards the infant and asked, "Can you help?" while extending her hand with open palm above the smaller box. The infant then had 10 s to give a toy to E1, which was timed by E2 behind the curtain.

After infants shared a toy or the full time had elapsed, E1 went behind the curtain and E2 came out, removed all the toys from the trial, and began the next trial with a new toy set. Infants received the same selection criteria in a given condition (i.e. either minority 18% sampling or majority 82% sampling across trials) and participated in each of the 3 emotion conditions. The order of the emotion trials was randomised across all participants (between 6–9 infants in each possible 6 trial orders).

Coding

A trained research assistant naïve to the experimental condition coded the infants' first toy touched ("first touch") and first toy offered to the experimenter ("first offer") based off Kushnir et al. (2010). Reliability was assessed from 30% of the trials and interrater reliability demonstrated near perfect agreement for first touches (97.2%) and perfect agreement for first offers (100%).

A manipulation check ensured that the experimenter adequately communicated the emotion in each trial. A trained researcher selected which emotion was expressed for each trial then rated the expression as: 0 = unacceptable, 1 = dull, or 2 = acceptable. Interrater reliability of emotion expression codes was near perfect (96.7%). Only trials with an emotion expression rated as acceptable (98% of trials) were included in the analyses.

Table 1. Infants' First Touches and First Offers Across Emotion Trials and Conditions.

		18% condition		82% condition	
		First Touch	First Offer	First Touch	First Offer
Joy	Target	75%	82%	46%	42%
	Alternate	25%	18%	54%	58%
Disgust	Target	63%	65%	35%	35%
	Alternate	37%	35%	65%	65%
Sadness	Target	58%	45%	50%	50%
	Alternate	42%	55%	50%	50%

Results

Aligned with the study aims and Kushnir et al. (2010), Chi-square analyses were conducted separately for each emotion to determine whether infants in the minority (18%) condition differed from infants in the majority (82%) condition on which toy (i.e. "target" toy E1 previously selected or "alternate" toy she did not select) they first touched and first offered (see Table 1). Distinct from Kushnir et al. (2010), the toy infants first touched and first offered were also compared to what could be expected at chance.

A preliminary set of analyses examined possible practice or order effects on infant behaviour. The toy infants first touched ($p = .90$) and first offered ($p = .57$) did not correlate with the order in which the emotion trials were presented. Likewise, first touches X^2 (2, 138) = 1.01, $p = .61$ and first offers X^2 (2, 138) = 2.71, $p = .26$ did not differ between trial number. Because infants received each emotion trial in counterbalanced order in either the minority (18%) or the majority (82%) condition and infants were never compared with themselves in any analysis, subsequent analyses were entirely between-subjects.

First Object touched

Joy. First touch responses were significantly different between distribution conditions when the experimenter expressed joy, X^2 (2, 48) = 4.27, $p = .04$, $\varphi = .32$. Specifically, when joy was expressed, infants first touched the target object more often when the minority object was selected (75% of infants) than when the majority object was selected (46% of infants), replicating findings from Kushnir et al. (2010). However, first touch responses were not different from chance in either condition for (Binomial tests, $ps > .54$).

Disgust. Differences across distribution conditions of infants' first touch responses when the experimenter expressed disgust did not reach statistical significance, X^2 (2, 47) = 3.61, p = .06, nor did first touches differ from chance in either condition (Binomial tests, ps > .21).

Sadness. First touch responses did not differ across distribution conditions when the experimenter expressed sadness, X^2 (2, 48) = 0.34, p = .56, nor did first touch responses differ from chance in either condition (Binomial tests, ps > .83).

First Object offered

Joy. Infants' first offer responses differed significantly between distribution conditions when the experimenter expressed joy, X^2 (2, 46) = 7.77, p = .005, φ = .41. Specifically, when joy was expressed, infants in the minority sampling condition offered the target more often (75% of infants) than infants in the majority sampling condition (42% of infants). Accordingly, infants offered the target object above chance levels in the minority (Binomial test, p = .004) but not majority condition (Binomial test, p = .54).

Disgust. Likewise, infants' first offer responses significancy differed between distribution conditions when the experimenter expressed disgust, X^2 (2, 46) = 4.26, p = .04, φ = .30. Infants offered the experimenter the target object more often in the minority sampling condition (65% of infants), but conversely infants in the majority sampling condition offered the alternate object more often when the experimenter expressed disgust (65% of infants), though these differences did not reach statistical significance from chance (Binomial tests, ps = .21).

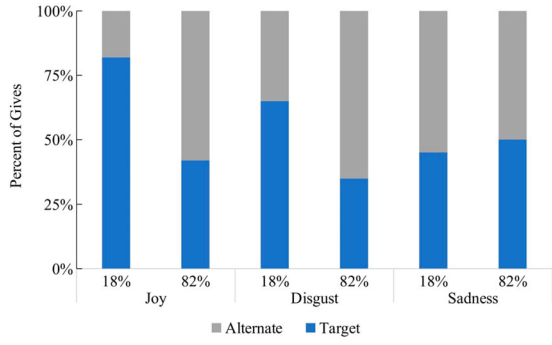

Figure 1. Percent of infants offering the target or alternate toy across emotion conditions and sampling conditions. Infants in the minority (18%) condition offered the target more often than the alternate toy compared to infants in the minority (82%) condition in the joy and disgust trials but not the sadness trial.

Sadness. Infants' first offer responses did not differ when the experimenter expressed sadness, X^2 (2, 46) = 0.09, p = .76, nor did the first offers differ from chance in either condition (Binomial tests, ps > .83). Specifically, infants were similarly likely to offer either toy in the minority (45% of infants offered the target) and majority (50% of infants) conditions.

Taken together, these results demonstrate that infants inferred intentionality from the selections when the experimenter repeatedly selected the minority toy and expressed joy or disgust, but not when she repeatedly selected the majority toy or when she expressed sadness in either condition (see figure 1).

Discussion

This study examined how 2-year-olds use discrete emotions to infer intentionality from statistical sampling events. Findings indicated that infants inferred an agent's intentional selection of an object when she expressed joy or disgust, but not sadness, after non-random sampling selections. To our knowledge, this is the first study to demonstrate that infants can infer intentionality from non-random sampling events in which an agent expresses a negative emotion after their selection. This novel finding complements a growing body of literature on infants' inferences from probabilistic sampling events and provides insights into how discrete emotions convey intentions.

The replication results in the joy trials bolster prior findings demonstrating that infants infer preferences from non-random sampling events (Kushnir et al., 2010; Ma & Xu, 2011; Wellman et al., 2016) and provide added confidence to the validity of our procedures given the inclusion of the novel negative emotion trials. Specifically, in line with our first and second hypotheses, we found that 2-year-old infants first offered the experimenter the target object when she expressed joy or disgust upon selecting minority (18%) objects out of the sample, but not when she expressed joy or disgust after selecting majority (82%) objects. Although the disgust results were not greater than chance, it is noteworthy that the pattern of results in the disgust trials mirrored those in the joy trials. In fact, a greater proportion of infants offered the target object in the minority condition after the experimenter expressed disgust

(65%) in the current study than infants who offered the target (58%) in the minority condition in Kushnir et al. (2010). This indicates that by two years of age, infants infer that an agent can intentionally select a preferred *or* an undesired object from a sample as a function of the discrete emotion.

The distinction between discrete negative emotions in our results provides insights into how different emotions communicate intentionality. In line with our third hypothesis, infants only inferred that the experimenter was making intentional selections by offering the target in the minority (18%) sampling conditions when she expressed disgust, but not sadness. Though sparse, some evidence suggests that infants understand that an agent may intentionally select a disgust evoking object but not one that would make her sad. For example, upon observing an experimenter express joy or disgust toward the contents of two cups, infants were not surprised when she later reached into either cup to retrieve the contents (Vaish & Woodward, 2010), but infants failed to attribute intentionality to an experimenter's action when she selected an object which had previously made her sad (Patzwald et al., 2018). This suggests that disgust, but not sadness, expressed after selections communicated intentionality.

The features of the discrete emotion expressions and their interaction with the sampling distribution also warrant consideration when examining infants' inference of intentionality from non-random sampling events. Notably, the inclusion of the experimenter's "oh no" verbalisation during her sadness expression may have provided infants with an additional cue that the experimenter's selection was unintentional. Moreover, sadness expressions have been shown to direct attention to the emoter, whereas disgust expressions direct attention to objects (Knothe & Walle, 2018). Therefore, the sampling distribution may have been more visually salient for infants during disgust trials than in sadness trials. This is important given that previous studies using joy presume that infants rely exclusively on the sampling distributions to infer intent. The lack of differences between conditions in sadness trials thus could have been because the experimenter's vocalisation reinforced unintentionality, infants only focused on the experimenter's emotional expression instead of the sampling distribution, or sadness was an irrational response to selecting minority objects. Conversely, the differences between majority and minority conditions in disgust trials may have been due to disgust directing infants' attention to the sampling distribution or infants offering disgust evoking objects to help decontaminate the sample. Indeed, Martin and Olson (2013) found that 3-year-olds only offered an experimenter dysfunctional objects when the task called for her to throw them in the trash and infants are less helpful to agents who express sadness in inappropriate circumstances (Chiarella & Poulin-Dubois, 2018). This supports the notion that disgust communicated contamination while sadness was an irrational response to selecting minority objects, but the interaction between discrete emotions and statistical sampling events necessitates further investigation.

Future directions

This study illuminates important avenues for further research examining the role of discrete emotion communication in statistical sampling events. Future work could investigate whether young infants expect agents to intentionally select disgusting objects out of a sample as they do with preferred objects (e.g. Wellman et al., 2016), as the developmental trajectories of infants' ability to infer intentions from discrete emotions necessitates further examination. Although the participants in this study were somewhat older than those in Kushnir et al. (2010), infants' understanding of agent dis-preferences is thought to develop later than understanding of preferences (see Reschke et al., 2017a) and our sample is more socioeconomically diverse compared to that used in prior research, making this replication and extension of previous findings particularly noteworthy.

Taken together, findings from the present study serve to motivate future investigations examining how the interplay of discrete emotions and statistical regularities in the environment interact to inform infants' understanding of the social world.

Author note

The authors do not have any conflicts of interest. The data and examples of the emotional expressions and stimuli used for this study can be accessed as supplementary materials (https://osf.io/zk3a5/).

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