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Developing Intuitions about How Personal and Social Properties Are Linked to the Brain and the Body

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This study investigated the development of intuitions about which properties are associated with the brain and which are associated with the body. A sample of 60 children aged 6, 8, and 10 years, as well a sample of 20 adults, were told about a brain transplant between two individuals and were asked about where certain properties resided after the transplant. Adults and older children construed the characteristics associated with fine-motor behaviour, culpability, social contract and best friendships as transferring with the brain. Characteristics associated with gross-motor behaviour, physical/biological properties, ownership and familial relationships were more likely to be seen as remaining with the body. Domain-based explanations for this pattern of results are discussed. Copyright © 2011 John Wiley & Sons, Ltd.

Key words: brain transplant; personal and social properties; categories; domain specificity

In science fiction stories, people escape from damaged or dying bodies by having their brains moved to other bodies. From the standpoint of neuroscience, this makes sense—personal properties such as consciousness, memory and the experience of free will are assumed to be the product of brain functioning. Even if one is a dualist and believes that a person's mind (or soul) is immaterial, still, it is often assumed that mental life is tied to the brain. Descartes, for instance, viewed the self as connected to the material world via the pineal gland, and Popper and Eccles (1977) titled their classic defense of dualism, 'The self and its brain.'

Most adults, then, share the intuition expressed by Daniel Dennett (1978): A brain transplant is the only transplant in which it is better to be the donor than the recipient. North American young children have some appreciation of the special role of the brain, presumably because details about the brain are a standard unit of the science curriculum in many elementary schools and educational media.

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Four-year-olds believe that thinking is a covert act that is done in the brain (Flavell, Green, & Flavell, 1995). By third grade (8 years of age), children consistently judge that the brain is needed for acts such as pretending or brushing one's teeth (Johnson & Wellman, 1982; Lillard, 1996), and they also realize that characteristics such as habits would transfer to the other character upon a brain transplant, whereas physical characteristics would stay with the body (Johnson, 1990). Children at these ages also reliably believe that a horse with a cow's brain would now think like a cow—thinking about giving milk as opposed to running fast in the field (Gottfried, Gelman, & Schultz, 1999; see also Bloom, 2004, for review).

Domain specificity and Localizing Properties

How might children come to have differentiated intuitions about brain-based and body-based properties? Young children may have a sense of distinct domains of mental activity and map these differently on the body and the mind. This would be one facet of the developmental process of learning that different domains have different causal properties (Hirschfeld, 1994). For instance, when discriminating between animate and inanimate objects, growth is characteristic of the former, but not the latter (e.g. Rosengren, Gelman, Kalish, & McCormick, 1991). In general, such domain-specific thinking underlies children's conceptual understanding. For certain foundational domains (e.g. physical, Spelke, Breinlinger, Macomber, & Jacobson, 1992; biological, Inagaki & Hatano, 2006; Keil, 2003; and psychological, Perner, 1991; Wellman, 1990), young children understand that particular properties and causal patterns support inferences and attributions about those properties in the context of each domain (Erikson, Keil, & Lockhart, 2010; Legare, Gelman, & Wellman, 2010).

Traditionally, domain-specificity claims have revolved around the large domains of physics, psychology and biology (Carey, 2009). Some properties are easily understood and categorized: thinking is allocated to the brain or mind, whereas running is allocated to the body (see Gottfried et al., 1999; Johnson, 1990; Johnson & Wellman, 1982 for developmental data). But, now consider certain more abstract social properties. Several studies have examined children's understanding of relationships (Allan, Hawker, & Crow, 2008; Newcomb & Bagwell, 1998), culpability (Rothman, 1976; Ttofi & Farrington, 2008), social contracts (Barrett, Keller, Takezawa, & Wichary, 2007) and ownership (Friedman & Neary, 2008; Blake & Harris, 2009; Kim & Kalish, 2009). These four social categories represent different forms of relational constructs that are salient in early childhood (Bugental & Goodnow, 1998) and, as such, offer an opportunity to contrast brain-based versus body-based attributions. One can ask questions such as the following: Are blood relationships encoded in the brain or the body? If a person's brain is largely destroyed, is she still culpable for past misdeeds? Is she still bound by an agreement that she made in the past? Does she still own her clothes?

It has been found that children do seem to have particular domain-specific expectations about some social phenomena such as child-caregiver attachment relationship, which they see in psychological terms (Bugental & Goodnow, 1998) and race, which they see in biological/essentialist terms (Hirschfeld, 1994; see also Crusec & Davidov, 2010). In a similar manner, children may consistently assign social properties in relations with other people to the brain (e.g. making a promise) and others to the body (e.g. having a sister). We explore such contrasts in the study

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below as they would provide an illustrative case study that bears on the broader question of how domain-specific social expectations develop in children.

Differentiation of Social Properties between the Brain and the Body Based on Intentionality

There are intuitive distinctions across the ownership, relationship, culpability and social contract categories. Ownership might be seen as corporeal, and hence body based, because one often owns physical objects such as cars and clothes. Social contracts might be seen as more psychological and hence brain-based, because it critically involves certain psychological states such as volition (e.g. promising someone to join a trip). More specifically, children might distinguish these categories on the basis of the perceived role of intention.

Children explicitly grasp the concept of intention tied to simple action at around 3½ to 4 years of age (Feinfield, Lee, Flavell, Green, & Flavell, 1999; Lang & Perner, 2002) and show an implicit understanding far earlier—for instance, see Bloom (2000) for a discussion of how children's capacity to discern the communicative intentions of others underlies the acquisition of word meanings. Yet young children seem to have difficulties in making more fine-grained inferences about links between actions and intentions. Thus, when they are asked about an identical behaviour displayed by two characters (e.g. running), even when they are told the goal of the behaviour differs for each character (e.g. exercise versus running away), four-year-olds' attribute the same intention to both (Baird & Moses, 2001). It is only much later in middle childhood that children have a mature capacity to identify intentions when the goals are not explicitly specified, such as distinguishing between the intentions of sarcasm and irony (Glenwright & Pexman, 2010).

Children's grasp of intentions may coincide with their ability to categorize social properties in an intuitively meaningful manner. When considering social properties, which pertain to relations with others, intentionally elicited properties and actions would be judged to be brain-based and unintentionally elicited properties and actions would be judged to be body-based. Although Bob might intentionally promise his sister that he will be careful of snakes at the resort (likely to be seen as brain based), he is not Sue's brother by choice (likely to be seen as body-based). It is important to note that this pattern is likely to hold specifically for social properties; a different pattern is expected with personal properties, which pertain to an individual's mental, physical and behavioural attributes. Although mental states are expected to be intuitively associated with the brain, they are typically considered to be non-intentional and intrinsic, for we can hardly control the emergence of a psychological state, such as thoughts, feelings and desires (see Flavell & Green, 1999; Flavell, Green, & Flavell, 1998; Flavell, Green, Flavell, & Lin, 1999). On the other hand, physical activities—likely to be seen as body-based—are often intentional (Schult & Wellman, 1997; Montgomery & Lightener, 2004). For example, although Bob may be able to stop himself from walking away from a snake by just deciding to do so, he cannot stop believing that snakes are dangerous via a mere exercise of will. Thus, the difference between self-related (or personal) and other-related (social) properties may lead to different ways of linking intentions to brain-based and body-based properties.

The present study, by examining a broad and systematic variation of properties and category types, addresses the following key question: At what point in development do children come to see personal and social properties as being linked to the brain and body in different ways?

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METHOD

Participants

This study included 20 first graders (10 boys and 10 girls; $M = 6;8$, range = 6;3–7;1), 20 third graders (11 boys and 9 girls; $M = 8;8$, range = 8;2–9;3), and 20 fifth graders (9 boys and 11 girls; $M = 10;8$, range = 10;4–11;3). The children were from elementary schools in a greater suburban Northern Virginia area and were mostly from middle class to upper middle class socioeconomic households. Twenty adults (10 men and 10 women, $M = 21;6$; range = 18;2–22;7) were recruited from the undergraduate student population at Yale University as part of requirements for an Introductory Psychology course.

Materials and Procedure

In line with previous studies on children's brain-body distinction across different properties (Johnson, 1990; Gottfried et al., 1999), the method of a hypothetical brain transplant was used. To aid in the presentation of the materials, children were presented with an 8×11-inch line drawing of two characters (either both boys or both girls). Half of the participants were randomly assigned to the boy condition, and the other half were assigned to the girl condition. The head portions of the drawing had small windows that could be lifted upon which the pictures of the coloured brains became visible (one brain was red, and the other was blue). Two arrows were drawn between the characters at the head level to indicate a transplant between them by scientists in the future (see Figure 1). Adults were presented with the same vignette and questions on a questionnaire with a 4×3-inch drawing, and they were asked to mark their answers on the questionnaire.

Participants were given the following introductory vignette: 'In the future, scientists can do a lot of things that they can't do now. See these two girls—Lori and Sally? And, look (lifting the head portion)—Lori's brain is red, but Sally's brain is blue! In the future, suppose the scientists take the brain out of Lori's body and put it into Sally's and also take the brain out of Sally's body and put it into

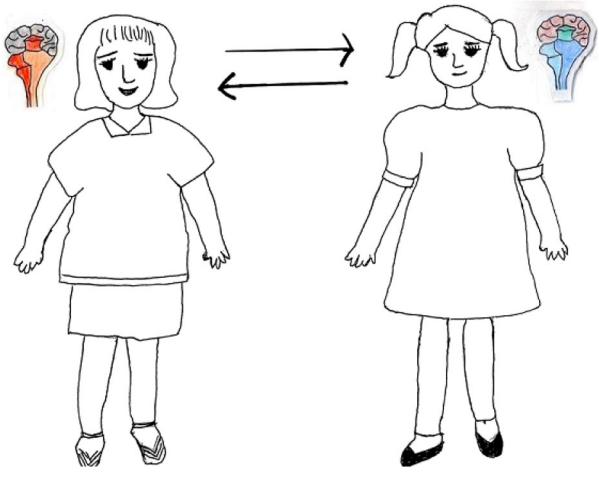

Figure 1. Depiction of two characters.

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Lori's (demonstrating the brain switch). After they do this, Lori's brain is in Sally's body, but the brain is still going to work just fine.' To ensure that children were not confused about the transplant procedure, immediately after the introductory vignette, the experimenter asked three control questions about the brain transplant described: (1) What did the scientists do, (2) Where is the red brain now, and 3) Who would the girl in Sally's body with Lori's brain look like—Lori or Sally? Five children incorrectly answered one or more control questions. The experimenter, in these cases, repeated the vignette and asked the question again. If the participant still did not answer correctly the second time, the experimenter corrected the response.

There were eight categories in total—four personal categories and four social categories. Each of the eight categories consisted of three questions (see Table 1). Test questions pertained to whether a property moved to the brain recipient or stayed with the original person (e.g. 'Before the scientists switched the brains, when Lori had Lori's brain and Lori's body, she promised someone she would take care of his flowers. But then, the brains were switched. Which girl needs to take care of the flowers now? The girl with Lori's brain or the girl with Lori's body?'). To ensure that participants' answers were not influenced by the particular order of the questions, the order was preset such that participants never received two questions consecutively from the same category. Participants were also asked to justify their responses.

RESULTS

To get a general assessment of whether participants conceived of individual properties as brain-based or body-based, participants were given 1 when they judged a property would move to the brain recipient (brain-based) and 0 when they judged it would not move (body-based) upon brain transplant. Each participant's mean score on the three items per category, therefore, ranged from 0 to 1. Preliminary analyses showed no significant effects of the participant's sex, the characters' sex or the order of presentation of the questions, and all subsequent analyses were collapsed across these variables. In this section, the data are examined across the categories, the items and then the justifications.

Table 1. Categories and questions

Physical	Having freckles all over back	Ownership	Owning a bike
	Having six toes on foot		Owning a puppy
	Being the cutest at school		Owning a computer
Biological	Having sores in stomach	Relationship	Having a best friend
	Having a large stomach and eating a lot		Having a boyfriend/girlfriend
	Not digesting milk well		Having a sister/brother
Behaviour (gross-motor)	The worst at jumping	Culpability	Breaking glasses
	The worst at running fast		Cheating on tests
	The worst at carrying heavy things		Stealing money
Behaviour (fine-motor)	Blinking eyes a lot	Social Contract	Taking care of flowers
	Tapping feet fast		Keeping a secret
	Biting fingernails		Going to New York with someone

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An Age(4) × Category(8) two-way ANOVA yielded main effects for age ($F(3, 125) = 6.70$, $p < .001$, $\eta^2 = .72$), category ($F(7, 512) = 43.20$, $p < .001$, $\eta^2 = .58$), and an interaction between the two ($F(21, 512) = 7.20$, $p < .001$, $\eta^2 = .62$). Below, we discuss the results in terms of age differences within categories (assessed by follow-up one-way ANOVAs) and theoretically interesting contrasts between property types (assessed by paired-samples *t*-tests). We also used one-sample *t*-tests to compare each mean score against a chance value of 0.5.

Personal Properties

The mean scores of brain-based responses for the physical, biological, behavioural (gross-motor and fine-motor) categories are shown in the first four sets of bars in Figure 2. According to the results of one-sample *t*-tests, as expected, the older participants consistently made the body-based responses at significantly below chance levels in physical, biological and gross-motor behaviour categories; in contrast, their brain-based responses in the fine-motor behaviour category were above chance by the third grade. Furthermore, significant age differences were found in follow-up one-way ANOVAs for the physical ($F(3, 77) = 9.04$, $p < .001$, $\eta^2 = .57$) and biological categories ($F(3, 77) = 8.69$, $p < .001$, $\eta^2 = .49$). Specifically, the two oldest groups (fifth graders and adults) were significantly more likely than the two youngest groups (first and third graders) to think that the physical and biological properties were body-based (Tukey post hoc test: p's $< .05$). Also, one-way ANOVAs revealed significant age differences in gross-motor behaviour ($F(3, 77) = 4.73$, $p = .004$) and fine-motor behaviour ($F(3, 77) = 8.52$, $p < .001$). The third and fifth graders and adults responded that fine-motor behaviour was more brain based than did the first graders (Tukey post hoc test: p's $< .05$), and the adults judged that gross-motor behaviour was more body-based than did the first and third graders (Tukey post hoc test: p's $< .01$).

Behaviour was divided into two categories—gross-motor and fine-motor behaviours—to examine whether or not the participants thought of this in terms

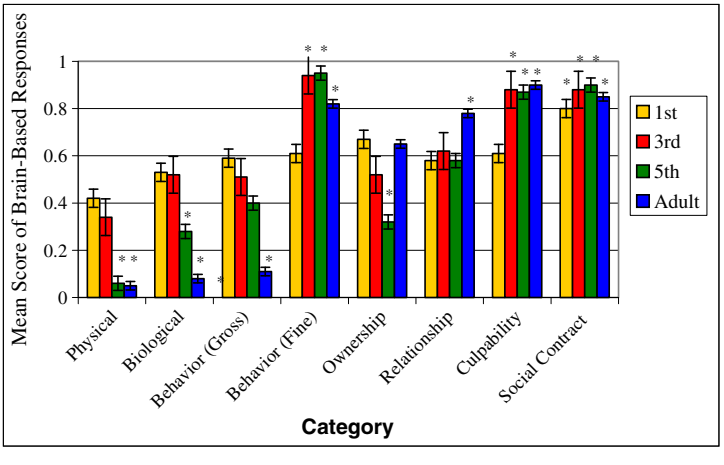

Figure 2. Mean brain-based responses for eight categories by four age groups. The *x*-axis indicates the eight categories, and the *y*-axis represents the mean scores of the participants by age as to whether the property stays with the body (0) or moves with the brain (1) upon a brain transplant.

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of a distinction between brain-based and body-based actions. Paired-samples *t*-tests comparing the responses to fine-motor and gross-motor behaviours indicated a statistically significant difference in the mean scores by the third grade ($t(19) = 4.10$, $p = .02$ in third graders; $t(19) = 5.98$, $p = .02$ in fifth graders; $t(19) = 8.03$, $p < .001$ in adults). That is, they judged gross-motor behaviours such as running as more likely to be body-based, whereas fine-motor behaviours such as tapping the feet fast were seen as more likely to be brain-based.

Social Properties

One-sample *t*-tests showed that, consistent with our expectation, the majority of the participants made the brain-based judgments in the culpability and social contract categories at above chance levels. One-way ANOVAs showed a main effect of age for culpability ($F(3, 76) = 4.77$, $p = .004$, $\eta^2 = .41$) and a trend of age for social contract ($F(3, 76) = 4.10$, $p = .058$, $\eta^2 = .38$), respectively. As illustrated in Figure 2, the third graders, fifth graders and adults were more likely than first graders to judge that properties pertaining to culpability (Tukey post hoc test: p's $< .05$) and social contract (p's $< .06$) would move from one character to the other when their brains were switched. In ownership, the mean score for the fifth graders was significantly lower than the other age groups (Tukey post hoc test: p's $< .001$). There were no age differences in relationship.

The significant interaction between the age groups and the categories nicely exemplified the hypothesized difference in attributing the brain's involvement in the four social categories. For all age groups but the first graders, the means of ownership and relationship were each significantly lower than those of culpability and social contract (paired-samples *t*-tests: p's $< .01$). In other words, they consistently judged culpability and social contract as more likely to move with the brain when the brains are transplanted.

In addition to the categorical distinction between the brain and the body, an unexpected finding across the items in relationship illustrated the extent of the participants' fine-grained differentiation. Each category consisted of three items (refer to Table 1); in the analysis earlier, these items equally represented the respective category as no statistical differences were expected across the mean scores of the items for all categories. Interestingly, however, the results of a mixed-design ANOVA that included age as the between-subjects factor and the three items in relationship—having a best friend, having a girlfriend/boyfriend and having a sister/brother—as the within-subjects factor indicated the main effects of item type ($F(2, 77) = 5.85$, $p = .03$, $\eta^2 = .59$) and age ($F(3, 77) = 7.29$, $p = .03$, $\eta^2 = .58$). The interaction between item type and age was not significant. The item type main effect demonstrates that children differentiate between interpersonal relationships in their judgments. According to paired-samples *t*-tests, by third grade, having a best friend was considered to be significantly more brain-based than having a sibling ($t(19) = 6.92$, $p < .001$, $\eta^2 = .41$ in third grade; $t(19) = 8.07$, $p = .002$, $\eta^2 = .53$ in fifth grade; $t(19) = 9.88$, $p = .04$, $\eta^2 = .32$ in adults; see Figure 3). Having a girlfriend or boyfriend fell consistently between having a sibling and having a best friend in all age groups, although it was not statistically different from either of the other two items.

Children's and adults' justifications to their responses confirmed the pattern of the results across the eight categories further. Three types of justifications were found—(1) body-based, (2) brain-based and (3) don't know/just because. Although a small number of the first graders' justifications were of the third type, most of the participants readily provided either brain-based or body-based

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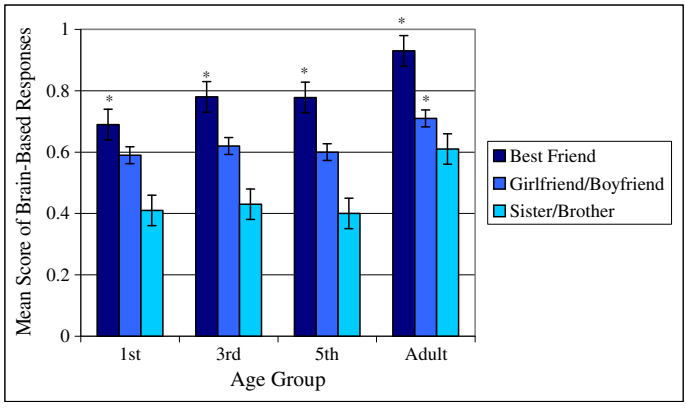

Figure 3. Mean brain-based responses for relationship items in four age groups. The *x*-axis indicates the age groups, and the *y*-axis shows the mean scores of participants who favoured the transfer of the property upon the brain transplant.

justifications in support of their responses. Those who thought certain properties would stay with the body after the brain transplant explained that the brain is not needed for those properties (e.g. 'You don't need the brain to have freckles,' 'The brain doesn't determine if there are sores in your body,' 'Jumping has more to do with your muscles than the brain,' 'Brains don't ride bikes; bodies do,' 'David's sister lives with David's body in the same house'). On the other hand, those who judged that a property would move to the other character with the brain reasoned that the brain is used for the particular property (e.g. 'The brain controls the nervous system, and it tells the feet to tap,' 'Lori's brain remembers the promise,' 'His brain told him to cheat'). Other than the differences between the brain-based and body-based responses, the justifications did not differ across the age groups.

DISCUSSION

Children's and adults' judgments about the inherent nature of different property types were examined across both personal and social properties, using a method in which they were told about brain transplants between two individuals.

For personal properties, the fifth graders and adults judged that physical and biological properties stay with the body upon a brain transplant. The emergence of this differentiation by the fifth grade in the current study, rather than by the third grade (see Johnson, 1990; Gottfried et al., 1999), is surprising. However, the justifications of the majority of those third graders who responded that physical and biological characteristics would transfer with the brain suggest that these responses have to do with their growing understanding (or misunderstanding) of what the brain does (e.g. '[Sally's] body will do things differently (producing freckles) because the brain controls the whole body,' or the transplanted brain will 'tell the stomach to grow ulcers.' A similar pattern of reasoning was observed for the third graders' chance-level responses in gross-motor behaviour. Several children reported that they started learning about the details about the brain in third grade; the aforementioned justifications might reflect the third graders' emerging knowledge about the multifaceted functions of the

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brain—it monitors the body's basic processes, coordinates physical movement, perceives, thinks and feels.

Pertaining to gross-motor and fine-motor behaviours, the children by third grade indicated a nuanced understanding of the brain's role across different activities. Jumping was judged to be highly body-based—presumably because this property was thought to be more closely tied to muscles and bones and required little in the way of knowledge. This was thought to be different from a capacity such as eye blinking, which was judged to be brain-based presumably because one has to engage in deliberate facial actions. This dichotomization accords with the findings from a preliminary study (Choe, 2005) in which the third and fifth graders identified wanting to buy a game as brain-based and liking ice cream as body based. Wanting to play a game is a cognitive activity, whereas taste is not. As one child put it, taste buds 'don't even connect to the brain.'

The main focus of the present study was how children and adults made sense of the properties of ownership, relationship, culpability, and social contract. Children by third grade and adults judged the properties pertaining to culpability and social contract to be more brain-based than ownership and relationship. Furthermore, although relationship was thought to be overall more body-based than were culpability and social contract, within relationship, the third and fifth graders and adults judged that friendship relationships were more brain-based than kin relationships. One chooses one's friends, not one's siblings or parents (e.g. 'Lori's friends with her because she likes her personality and attitude,' 'Both David and his brother came from their mom's stomach'). This fine-grained distinction indicates that children's judgments are not merely primed by their previous responses to similar questions in a category but that they follow a rich pattern of reasoning.

The sorts of distinctions among social properties explored here are not explicitly taught, nor are they as straightforward as the personal properties explored in previous work (e.g. thinking as brain-based and running as body-based). How do children come to know them?

One possibility is as follows: Even young children can explain and make causal inferences across a variety of domains (Bullock, Gelman, & Baillargeon, 1982; Schulz & Gopnik, 2004; Sobel, Sommerville, Travers, Blumenthal, & Stoddard, 2009) because they have different causal models of how the properties become manifested (Sloman, Lombrozo & Malt, 2004). Making causal inferences in the social domain might be especially crucial in interpersonal relations because it allows people to predict and explain others' behaviours and to attribute responsibility and blame (Alicke, 2000; McClure, Hilton, & Sutton, 2007). As intentional actions are judged as more causal than unintentional ones (Lagnado & Channon, 2008), an assumption of accountability, in turn, leads self-directed and goal-driven properties (such as culpability and social contracts) to be brain-based. Properties such as family relationship and ownership, on the other hand, are neither self-propelled nor goal-driven in the same sense, and hence are seen as more likely to be body based. This is seen in children's repeated references to the character's relationship with the parents and home in their justifications, rather than imbuing a goal-based responsibility to the character.

These findings suggest that, although they are largely implicit, domain-based inferences in localizing the social properties follow coherent principles. They invite more research on subtypes of social categories, attributes and relations (e.g. the effect of the explicit presence or absence of intention in localizing social properties and the extent of cross-cultural variation). This is an exciting area of work, as children's and adults' understanding of these complex domains bears critically on how we think about ourselves and others.

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