Young children's reasoning of artifact function across different contexts: an action-protest paradigm

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ABSTRACT

Information at the core of young children's artifact representation, such as function and categorisation has been central to current research on representation of artificial kinds. Previous studies have found that adults consistently favour the original intended function over an idiosyncratic or conventional use. However, the developmental findings in children are less consistent. This study examined young children's sensitivity to violations of the conventional use of artifacts and whether function is viewed normatively through employing an action-protest paradigm. The aim of this study was to observe children's spontaneous responses to alternate uses of everyday objects which violated conventional functions. Eighteen 3-years-olds and nineteen 4-year-olds were shown, typical or atypical functions of three everyday artifacts by a puppet. A second puppet subsequently used the artifacts in a different way to the first puppet. Children's implicit and explicit protests were coded. Overall, 3- and 4-year-old children protested more to violations of the first demonstrated function, irrespective of whether the second demonstration was used in a conventional, idiosyncratic or instrumental manner. These findings suggest that the action-protest paradigm measured protest against the first function demonstrated or rule provided. Results are discussed in light of the current literature on normatively structured game-like contexts and children's artifact reasoning.

KEY WORDS:	YOUNG CHILDREN	ARTIFACTS	FUNCTION	NORMATIVITY	ACTION-PROTEST PARADIGM

Introduction

An essential part of everyday life is the way in which people interact with the vast array of man-made objects or artificial kinds, from simple tools like cups and spoons to much more technologically sophisticated machinery (Tomasello, 1999). Imagine a classroom full of young children going about their daily learning activities, the teacher comes around and places a coffee mug in the centre of each desk, inside of which are an assortment of pens and crayons. At break-time the teacher goes to the staffroom and pours herself a mug of coffee. The teacher in the classroom presumably understands what mugs are essentially for, and the mug even though being used for another plausible function, to hold pens, does not lose its essence of 'mug-ness' and its primary function. After all, the reason the mug came into existence was not to hold pencils but to hold coffee and thus function as a coffee mug and not a pen holder (Bloom, 1996; Kelemen & Carey, 2007).

Furthermore, although an individual may use an artifact in an idiosyncratic way, invariably an artifact is used in the manner which it was intentionally created (Bloom, 1996; Kelemen 1999a) or as defined by social convention (Callanan, Siegel & Luce, 2007; Diesendruck, Carmel & Markson, 2010; German, Truxaw, Defeyter &, 2007). In the majority of cases the conventional use of an artifact is in accordance with its designed function, if it were not, production lines across the world may well come to a standstill.

There is considerable debate about how children reason about artifacts and how an understanding of artifacts develops conceptually. Research within the field of cognitive development suggests that infants are born with innate core knowledge systems, which enable the young mind to grasp and make connections with the plethora of stimuli and information around them (Spelke & Newport, 1998).

This genetic foundation enables very young children to rapidly develop reasoning abilities with regard specifically (but not only) to objects. This core knowledge perspective advances the idea that children are sophisticated at developing cause and effect explanations, testing their own ongoing theories about the observations and experiences they engage in, and forming specific representations in the process (Gelman, 2003). According to this perspective, there is the suggestion that a core knowledge domain specific to artifacts serves as a guide to identifying and representing everything needed for explaining the intentional design of an artifact (Kelemen & Carey, 2007).

Others, however, have proposed that artifact representation involves the integration of different knowledge domains including an understanding about object mechanics (Pinker, 2002), and the role of social information (Defeyter & German, 2003; Defeyter, German & Avons, 2007). In addition to core knowledge theory many researchers emphasise the role of sociocultural contexts (Callanan et al., 2007; Vygotsky 1978) and meaningful everyday activity (Rakoczy, 2007; Tomasello, 1999) in forming artifact concepts.

Mature artifact conceptualisation involves the capacity to represent and reason about the mechanical properties of an object; its material kind and its structure and shape,

all of which limit its motions, potential interactions with other objects and the range of functions it can carry out (German et al., 2007; Gibson, 1979). However, mechanical properties do not completely determine the primary function of an item. A glass has similar properties to a vase, and both could hold juice and flowers equally well, yet we understand them to serve different primary functions, one is for drinking from and the other is to hold flowers. This suggests that other sources of information must be important when deciphering what an artifact is for (Bloom, 1996; German et al., 2007).

Many studies on natural kind concepts have shown that adults reason that natural kinds such as animals and humans, have causally deep essential features, for example genes, which are often unseen and thus go beyond an object's perceptual properties (Gelman, 2003; Medin & Ortony, 1989). This essentialist theoretical framework lends itself to much of the research on artifact conceptualisation, proposing that artifacts too have a distinctive social and psychological causal basis, i.e., the creator's intentions (Bloom, 1996). Bloom suggests that when people categorise artifacts it is not physical features and function alone that determine category membership. Artifacts are embodiments of intention and by their very nature have been created to belong to a specific category with a specific function. Thus a vase is a vase and not a glass because it was designed to be a vase. The term "design stance", which has been appropriated from Dennett (1987), is used to refer to this explanatory framework. Studies with adults have found that although other factors such as appearance, context and current use are important, the deepest causal factor and overriding cue to adult's artifact categorisation is the original intended design (Kelemen, 1999b; German & Johnson, 2002). This core property is arguably the key to understanding how adults intuitively reason about artifacts (Bloom 1996; Kelemen, 1999a; Matan & Carey, 2001; Defeyter, Hearing & German, 2009; Kelemen & Carey, 2007).

Studies have found that adults weight original intended function of an artifact over properties such as form (Rips, 1989) and favour the original function when it is pitted against a current or idiosyncratic use by another person in function judgement tasks (German & Johnson, 2002; Kelemen, 1999b,) and in categorisation tasks (Matan & Carey, 2001). This suggests that the category an artifact belongs to and the original function it was designed to serve are more important cues than an intentional idiosyncratic use in mature artifact reasoning. These studies support the view that adults intuitively know how to use artifacts in the 'right' way by appealing to the original intentions of the designer.

Furthermore, support for the design stance has been found not only in technologically advanced societies, where one would expect a sensitivity towards design intentions given our daily exposure to mass produced artifacts, but in technologically sparse hunter-gatherer societies. These studies employed function judgement tasks (Barrett, Laurence & Margolis, 2008) and problem-solving tasks (German & Barrett, 2005) with young adults and found design information to be a core property in adult's artifact conceptualisation providing support for the design stance as a universal aspect of human cognition.

Whilst the adult data is fairly consistent regarding categorisation and function judgements via this explanatory framework, research investigating whether or when children reason using design information is somewhat mixed. Previous research suggests that design information does not provide the core meaning of artifact terms until about 6- or 7-years-old. Prior to this, younger children have demonstrated consistent shape bias when categorising artifacts (Landau, Smith & Jones, 1998), or have shown immunity to functional fixedness in problem-solving tasks (Defeyter & German, 2003) and 5-year-olds have generated significantly more novel functions for everyday artifacts than 7-year-olds in functional fluency tasks (Defeyter et al.,2007).
By contrast, other research has found evidence that 3- and 4-years-olds use information about design intentions to make judgements about function (Kelemen, 1999b; Kemler Nelson, Herron, & Morris, 2002) and category membership (Gelman & Bloom, 2000; Jaswal, 2006). In many of these studies investigating children's artifact conceptualisation, the tasks that are often employed use novel and/or familiar artifacts and pit the original function against an alternate current function. This methodology requires children to make a function judgement ('What's it for?') or a category judgement based on function ('What is it?').

Kelemen (1999b) used a function judgement task in which 4- and 5-year-olds and adults were presented with pictures of novel artifacts designed for a specific function (e.g. to stretch clothes). The degree of intent was manipulated so that subjects were told that the artifact was now being used by an individual (a friend of the owner of the clothes-stretcher) for a different purpose (e.g., to exercise a bad back); either once or many times accidently or intentionally. When asked what the object was for, in all conditions, children and adults overwhelmingly answered it to be for stretching clothes, the original intended function. Kelemen argues that these results demonstrate that children reason from a design stance as early as 4-years-old.

In contrast, German and Johnson (2002) found no evidence of preschoolers using design information when pitting original function against an intentional alternate function. The goals of the original designer were not privileged over any other successful goal-directed use. This suggests that if an artifact is purposefully used in a plausible alternate way then younger children are open to this viable alternative when making judgements about function. However, despite their failure to use design in their function judgements, preschoolers, like adults, significantly used the original category label (e.g., "a tog") when asked "what is it?" The authors suggest that children employ a 'creator-category rule' (p265) when making categorisation judgements. An important distinction to make therefore is between categorisation judgement tasks and function judgement tasks in understanding the role of convention and design in artifact conceptualisation in adults and children.

Matan and Carey (2001), in a categorisation task, presented 4-year-olds, 6-year-olds and adults with pictures of partially hidden artifacts which had been made for one function (e.g., to make tea) but were currently being used for another (e.g., to water plants). Using a forced choice paradigm subjects had to decide whether the artifact was in the category of 'teapot' or 'watering can'. Six-year-olds and adults overwhelmingly favoured the category associated with the original intended function. Four-year-olds however, did not always do so and preference was just above chance

levels, suggesting that design based decisions do not develop until around 6 years old.

In a similar study Keil (1989) found contrasting results when pitting the original function against a plausible current function. Four-year-olds, 6-year-olds and 10-year-olds were presented with pictures of familiar artifacts (e.g., a coffeepot) accompanied by a description and picture of alterations that changed the appearance and function of the item (e.g., the coffeepot was transformed into a birdfeeder). All age groups favoured the current function when asked to choose between the label associated with the original function and the label associated with the current function, finding no evidence of reasoning from a design stance in children up to 10-years-old.

Evidently many studies have found contrasting results regarding the age by which children appeal to the design function when reasoning about artifacts. This in part could be due to the conceptual differences in the tasks used to measure how children reason e.g., categorisation judgement tasks and function judgment tasks. In recent developmental studies, significant dissociations between category and function judgements have been demonstrated in 4- and 6-year olds (Defeyter, German & Hearing, 2009). The studies found that regardless of whether the function was the original or a conventional (many users) or idiosyncratic (individual user), it was the intentionality of use that influenced function judgements. Design intentions were not favoured over other intentions, suggesting that young children do not organise their understanding of artifacts around a core notion of design function. However, when children had to choose between two category labels based on the original function and an alternate function in a forced-choice paradigm task in the same study, both age groups privileged designer's intentions over an alternate category by a single idiosyncratic user. This suggests that children adopt a strategy whereby they use the artifact's category label to infer the designed function, whereas function judgements do not operate in the same way (see also German & Johnson, 2002).

Category labels serve as a means of communication through the use of language and as such are not bound by the same mechanical properties as artifacts in relation to function. Thus an object can have many plausible functions but a mug is still labelled a 'mug' whether it's being used to hold coffee, pencils or a bunch of daffodils (German et al., 2007; Matan & Carey, 2001).

So although many studies present evidence of children as young as 4 years old reason from a design stance, it is worth making this conceptual distinction between categorising artifacts and judging functions of artifacts. Children may show more flexibility when deciding on function than if they have to choose between two labels, the original and an alternative. This may in part be due to the conventionality of language and the way words hold meanings which are associated with specific images in memory, consequently any alternative is seen as a mistake (Kalish & Sabbagh, 2007; Malt & Sloman, 2007).

Additionally, the inconsistency in the data could be as a result of variations in methodologies employed. In function judgement tasks the order in which the origin of

the designed function appears in a story when pitted against its current use could influence how children and adults reason when asked 'what is it really for?' (Siegel & Callanan, 2007). Also, by asking subjects what the artifact is 'really' for implicitly gives more weight to the original function than to any current use which could bias responses in a design direction.

By their very nature, forced–choice paradigm tasks demand that participants choose between two options, design function and current or idiosyncratic function and perhaps this does not adequately reflect how people reason about categories in real life (Malt & Sloman, 2007). It has been argued that adults as well as children may well use "some systematic basis for choosing" (p116) which could have little to do with how design informs judgement decisions. The experimental paradigm may not tap important underlying mechanisms thus children particularly, may give the answer they think the experimenter wants to hear (Malt & Sloman, 2007; Barrett et al., 2008; Siegel & Callanan, 2007).

In contrast to the design stance theory, other researchers have found that artifact categorisation is dependent on the immediate context and the current task where physical features are given more weight than original design (Landau et al., 1998). Alternatively, conventionality assumes that artifacts are, to a degree, typically used in the designed way, and research suggests that there is shared agreement among a community about the conventionalized functions of artifacts based upon how a community uses that object (Callanan et al., 2007; German et al., 2007; Siegel & Callanan, 2007). Therefore, even if an individual was to use an artifact in an idiosyncratic way like the teacher's use of the coffee mug as a pen holder, this does not change its stable conventional function or shift the community understanding of the 'proper' intended function. Moreover, the function of an artifact may change over time as the needs of a community change, making redundant the intentionally designed function. For example, pipe cleaners were originally intended to clean smoking pipes, but nowadays the conventional use in many communities, is to make different coloured shapes in arts and craft activities (Defeyter & German, in preparation).

The role of shared convention has been identified within this perspective as being an important aspect in how children reason about artifacts (Siegel & Callanan, 2007). In every context there are socially governed rules, whether they are strict laws, cultural norms, conventional ways or idiosyncratic practices, many of which are strictly adhered to. If an individual breaks the law (rule) there is a consequence. But others are more negotiable and flexible through language and action such that it can be agreed upon to use a coin to serve as a missing 'pawn' in a game of chess or using a mug as a pencil holder (Bloom 1996; Callanan et al., 2007). Although artifacts are seen as having a conventional function, often the context in which an artifact is used is relative to whether or not an artifact's use is seen as a violation.

The importance of the contextual nature in which artifacts are used was demonstrated in an amended replication of a study by German & Johnson, (2002). Siegel & Callanan, (2007), found that when an artifact's function had changed because *many* people (rather than only one) had adopted a different use from the original function, 5-year-olds, 7-year-olds and adults were less likely to view the

artifact from a historical design perspective. Demonstrating that far from showing fixity in how objects were being used, children and adults can be flexible regarding the functions of artifacts particularly if there is community agreement. Further, this study suggests that it is conventional function rather than the design function which is a central component in how children and adults organise artifact concepts. However, does conventional knowledge about artifacts which even younger children seem to possess, have a normative aspect, to the extent that using an artifact in an atypical way is seen as breaking the rules and therefore a mistake?

In a recent study young children's normative awareness of artifacts was empirically tested to see if they believed there was a 'right' way to use objects (Casler et al., 2009). An action-protest paradigm was adapted from previous studies investigating sources of normativity in simple rule games (Rakoczy, Warneken and Tomasello, 2008; 2009). Casler and colleagues found that 2- and 3-year-olds demonstrated normative protests towards a puppet using artifacts in ways that violated the conventional function. These findings provide a strong indication that toddlers strongly believe that there are 'proper' ways to use objects and any other use is simply 'wrong'. Furthermore, this implies that young children view other plausible functions as mistakes which ought not to have occurred.

Methodological issues, however, could have limited the scope of the study. The conventional function was always demonstrated first during the familiarisation phase followed by a conventional, idiosyncratic or instrumental function in the test phase, the order was not counterbalanced. The problem with this is the child always had the conventional function primed, which could implicitly establish a 'rule' to be followed. Secondly, there is growing evidence to suggest that preschoolers show a preference for knowledgeable adult models over less knowledgeable peer models, and it is through adult models that normative learning readily occurs (Rakoczy et al., 2009). It seems possible that the toddlers in this instance could have based their responses on the first demonstrated function in the familiarisation phase which happened to be the conventional use. Perhaps the children were merely protesting to the puppet making a mistake in that context thus correcting him rather than seeing atypical uses as wrong per se.

The present study attempted to address these issues by replicating the study carried out by Casler and colleagues (2009) with three changes. To test whether children protested to violations of the conventional use and thus demonstrating normative awareness or whether they were protesting to violations of a 'rule', the functions were counterbalanced. Depending on the condition, some children saw, for example, an idiosyncratic function first in the *demo phase* followed in the *test phase* by a conventional function. Additionally, to account for any difference in preference regarding adult model vs. puppet model, the present study used two hand puppets to demonstrate the two functions in each phase.

The third change concerned the developmental difference found between 2- and 3-year-olds, with 3-year-olds showing more spontaneous protest than 2-year-olds. Previous research suggests that toddlers have yet to grasp artifact function in its fullest sense (Casler & Kelemen, 2007). This could have been a potential factor which prevented 2-year-olds from being able to explicitly criticise the puppet to the

degree 3-year-olds were able to, as could shyness and ability to articulate verbally. For this reason, the present study used 3- and 4-year -olds attending nursery or school to try and avoid any factors such as shyness.

The present study aimed to investigate 3- and 4-year-olds sensitivity to violations of conventional functions of everyday artifacts through employing an action-protest paradigm. If Casler and colleagues are correct then toddlers should only protest when the conventional function is violated. However, if toddlers are simply protesting to violations of the artifact's use 'in this context', then it would appear that children are somewhat flexible in terms of the use to which an object can be put across different function contexts.

Method

Design

In this study a 4 x 2 between subjects observational design was used. The first factor being function, compared different pairs of function orders consisting of a *demo phase* function followed by a *test phase* function in four orders: 1) conventional-idiosyncratic, 2) conventional-instrumental, 3) idiosyncratic-conventional 4) instrumental-conventional. Conventional function was the typical everyday function of each test item, e.g., a crayon used for drawing. Idiosyncratic function was operationalised as a use to which expressly violated the conventional function e.g., a crayon used for stirring liquid. Instrumental function was somewhere in-between as it did not necessarily violate the conventional function, yet it was a different use to the conventional function, e.g., a crayon used for tapping.

The second factor was age and compared 3-and 4-year-olds spontaneous normative protests in all four conditions. Normative protest scores constituted the dependent variable.

Participants

The sample consisted of eighteen 3-year-olds (12 girls, 6 boys, mean age 3.7) and nineteen 4 year olds (12 girls, 7 boys, mean age 4.4). Children were recruited from one primary school and two nursery schools in Birmingham, England and represented mixed ethnic groups and a broad range of socio-economic backgrounds. One additional child participated but was excluded due to prompting from the classroom assistant.

Materials

Three everyday objects were used as the test items: a toothbrush, a baby's bottle and a crayon. Objects were chosen on the basis that most children used them on a regular basis and would be familiar with their conventional function. Two puppets were used to demonstrate the functions, one was a bear called 'Sam' and the other a pig called 'Sally'. They were long sleeved hand puppets, with working hands and mouth. Other objects were required, such as play dough, to demonstrate atypical functions of the test items. Consideration of health and safety regulations meant that

a doll had to be used for the demonstrations rather than children putting the bottle and toothbrush directly in their mouth (see appendix A for a full list of additional items used).

A Panasonic camcorder, on a tripod, was set up in the corner of a quiet room in the nursery or school. A child-sized table was used to demonstrate different functions of the artifacts.

A second experimenter was needed to operate the *test phase* puppet, Sally. In this study, two qualified teachers who were known to the experimenter and were based at one of the participating schools, assisted in alternate testing sessions operating the *test phase* puppet.

Procedure

Once permission was granted from two nursery schools and primary school to carry out testing, ethical approval was then obtained from Northumbria University's Department of Psychology Ethics Committee (see appendix B). Participant information and consent forms (see appendix C and D respectively) were then sent out to all parents of children attending the two nursery schools and in the Reception class of the primary school. Testing commenced at the point where parental consent had been granted.

Children were tested individually in a room in their nursery or school. Sessions were videotaped and lasted approximately 20 minutes.

Warm up phase

Experimenter one (E1) and experimenter two (E2) first of all engaged the child in an unrelated activity to the experimental task, join-the-dots, the aim of which was to engage the child in conversation, and make them feel at ease with the experimental setting. At a certain stage in the warm up process the child was introduced to Sam and Sally who engaged the child in conversation until E1 had evidence that the child was comfortable with both puppets (e.g., smiling) and could engage with them (e.g., talking). This would ensure that any subsequent embarrassment or failure to interact during the test trials was not as a result of the child being uncomfortable with the puppets. At the end of this session Sally exited the room.

Following the warm up phase each child was allocated to one of four conditions in which an initial function was demonstrated by Sam followed by a test phase in which Sally came in and used the object in a different way to the demonstrated function. See Table 1 for a list of conditions, artifacts and functions. All functions (atypical and conventional) were plausible goal-directed actions.

Table 1
List of Conditions, Artifacts and Functions in the Demo and Test Phases

Condition	Object	Demo Phase	Test Phase

Conventional - Idiosyncratic	Baby Bottle Toothbrush Crayon	Feeding baby Cleaning teeth Drawing	Rolling play dough Brushing doll's hair Stirring liquid
Conventional - Instrumental	Baby Bottle Toothbrush Crayon	Feeding baby Cleaning teeth Drawing	Drawing circles Jabbing play dough Tapping
Idiosyncratic - Conventional	Baby Bottle Toothbrush Crayon	Rolling play dough Brushing doll's hair Stirring liquid	Feeding baby Cleaning teeth Drawing
Instrumental – Conventional	Baby Bottle Toothbrush Crayon	Drawing circles Jabbing play dough Tapping	Feeding baby Cleaning teeth Drawing

Demo Phase

With E2/Sally out of the room Sam said: "*Look I've got something I want to show you*". He put the object on the table. "*Here is a .... (*object, e.g*., bottle)*". "*This is how you use a (*object, e.g*., bottle) for (*function e.g*., feeding)*". Sam demonstrated the function. "*See, this is how you use a (*object, e.g*., bottle) for (*function, e.g*., feeding)*". Sam then said to the child, "*Would you like to have a turn?*"
The child then used the item in the same way that Sam had demonstrated. E1/Sam took the object back and modelled the function once again. "*See this is how you use a (*object*) for (*function*)*".

Test Phase

As Sam finished off his demonstration E2/Sally entered the room, exclaiming, "*Ooh! A (*object, e.g., *bottle)! I know how to use a (*object, e.g*., bottle). Is it my turn?"*
E1/Sam agreed, "*Ok, Sally it's your turn*". He passed the tool to Sally then distracted himself away from Sally and the child. Sally used the item in a different way to Sam. As she did this she said, "*I do this with a (*object, e.g., *bottle), I use the (*object, e.g., *bottle) for (*function, e.g., *rolling play dough)*". She performed the function for approximately 10sec. She paused, repeated the action, saying, "*I do this with a (*object*,* e.g., *bottle)*". When she finished, Sally said "*I've got to go now, see you later, bye*". Each child took part in three trials; bottle, toothbrush and crayon, following the same procedure of demonstration phase followed by test phase.

Participant debrief sheets were given to all parents whose children had taken part (see Appendix E). Upon completion of the whole study, a feedback sheet with the main findings was sent to each nursery and the primary school as well as to all those parents who had indicated on the consent form that they would like feedback.

Control question

At the end of the three trials, the child was asked by E1 to say the function of each test item, e.g., "What is the bottle for? This was done to see which function the child

had encoded. After testing each child was given a sticker and thanked then taken back to their playgroup or classroom.

Coding

The coding was extracted from the videotaped data. Observed levels of normative protest were coded at test phase to identify any difference between function and age. Additionally, demo phase protest was coded, to examine any difference across first functions.

Explicit and implicit protests were coded systematically using the same coding scheme as Casler et al., (2009). Overt protest was given 2 points which included explicit telling off, ("No! It's not for that!"), reporting to Sam about Sally's behaviour, ("Look what she did"), or attempting to teach the puppet how to do it the 'right' way, ("No, you do this...").

Less overt protest scored 1 point and consisted of implicit signs of normative awareness. This included, handing the correct objects over to Sally e.g., passing her the doll to clean teeth or gesturing towards the correct objects to be used, demonstrating attempts at teaching. Showing signs of amusement (incorrect actions are often seen as funny), looking quizzically over to E1 (as if something has happened which perhaps should not have) and scrutinizing the behaviour of the puppet which was operationalised as observing the puppets actions fixedly without motion for over 5 seconds.

An implicit and explicit score was given per child for each of the three test objects; bottle, toothbrush and crayon at *demo phase* and at *test phase*. For each child a sum score of total protest in the two phases was calculated and these provided the basis for statistical analysis.

Observer reliability

Videotaped data was assessed by a single observer. For reliability, a second observer who was unfamiliar with the study and blind to its predictions coded a random selection of 30% of the sessions; the resulting Pearson correlation coefficient for the interrater reliability analyses was very strong, .89, $p = .001$.

Results

This study investigated whether 3- and 4- year-old children demonstrated evidence of normative awareness about artifact function when faced with a puppet using everyday objects in atypical ways. If children viewed any actions as violations of the conventional function, i.e., if they viewed the puppet to be using the object in the wrong way, then they would show this in their spontaneous responses. Secondly, whether children's normative beliefs about artifact function would vary with age was also investigated.

The sum total of implicit and explicit scores for each child at *demo phase* and *test phase* was entered into SPSS as was age (coded as '1' = 3 years old and '2' = 4 years old) and condition (coded as '1'=conventional-idiosyncratic, '2'=conventional-instrumental, '3'=idiosyncratic-conventional, '4'=instrumental-conventional).

First, a 4 (type of function: conventional–idiosyncratic vs. conventional-instrumental vs. idiosyncratic-conventional vs. instrumental-conventional) x 2 (age: 3 year olds vs. 4 year olds) analysis of variance (ANOVA) was applied to the overall *test phase* protest scores. No significant main effect of function was present, $F(3, 29) = 0.399$; $p = .755$.

As can be seen in Table 2, there was no significant difference in mean protest scores between conditions at *test phase*. Nor was there a significant main effect of age present, $F(1, 29) = 0.853$; $p = .363$ or an interaction effect between function and age, $F(3, 29) = 1.221$; $p = .320$. The results found no significant difference in mean protest scores between 3- and 4-year-olds. The mean protest scores indicate that in all four conditions, both groups of children showed evidence of normative protest towards the second function demonstrated, irrespective of whether the artifacts were used in a conventional or unconventional manner.

Table 2
Total Mean Number of Protest Scores (and Standard Deviation in Parentheses) for Both Age Groups in Conditions at *Test Phase*

	n	**Test Phase**	
Condition		**3 year olds**	**4 year olds**
Conventional-Idiosyncratic	9	6.20 (5.07)	2.25 (2.63)
Conventional-Instrumental	9	2.40 (1.14)	4.75 (4.50)
Idiosyncratic-Conventional	9	6.00 (5.29)	4.67 (3.93)
Instrumental-conventional	10	4.60 (2.61)	3.20 (1.10)
Total		**4.67**	**3.79**

To investigate children's normative protest towards the first function demonstrated, an ANOVA was applied to the *demo phase* scores. It detected a significant main effect of function**,** $F(3, 29)= 3.079$; $p = .043$, however, no significant main effect of age was present, $F(1, 29) = 0.826$; $p = .371$ and no interaction between function and age was present either, $F(3, 29) = 0.770$; $p = .520$.

To find out which type of functions differed significantly from one another in the *demo phase*, post hoc comparisons were applied for this factor.

Tukey comparisons revealed that in the 'idiosyncratic-conventional' condition, children in both age groups demonstrated significantly more normative protest towards the idiosyncratic function (total mean 1.56) than those children in the other three conditions who were shown either a conventional or instrumental function in the *demo phase* (total mean = 0.00, 0.00, 0.00 respectively).

Additionally, a paired samples *t* test was applied to scores in the 'conventional-idiosyncratic' condition to examine whether children across the two age groups demonstrated more protest to the idiosyncratic functions in the *demo phase* or to the conventional functions in the *test phase*. As can be seen in Figure 1, analysis revealed that idiosyncratic *demo phase* scores (total mean 1.56) compared with conventional *test phase* scores (total mean 5.11) was statistically significant $t(8)= -3.411$; $p = .009$ (two-tailed). This suggests the manner in which items were used in the *test phase*, even though conventional, provoked children in both age groups to protest significantly more than idiosyncratic functions in the *demo phase*.

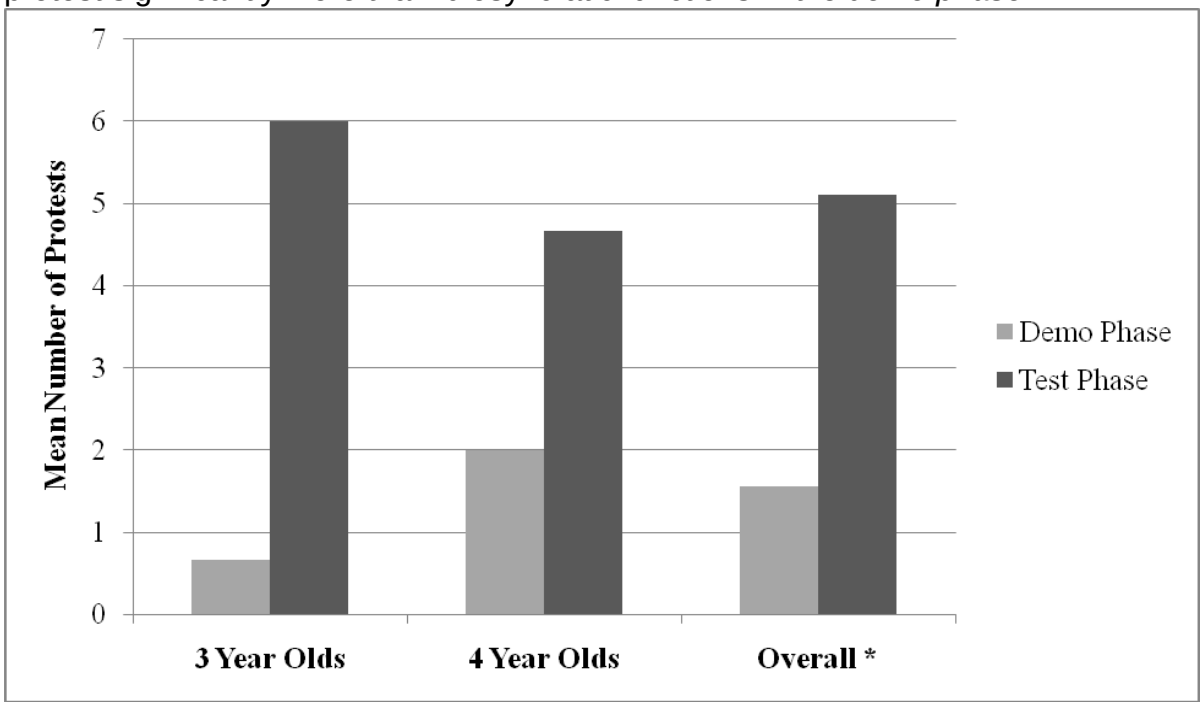

Figure 1: Mean number of normative protests for 3- and 4-year-olds and overall in the 'idiosyncratic-conventional' condition during the *demo* and *test phase*. Note: * $p < .01$

Overall, 3-and 4-year old children protested more towards the second function demonstrated than the first function, regardless of whether the second function was the conventional or non-conventional use. Children in both age groups performed above chance on the control question. When asked what each test item was for, 92% responded with the conventional function rather than any of the primed functions.

Discussion

The primary goal of this study was to explore young children's sensitivity towards violations of conventional functions of everyday artifacts by extending the application of an action-protest paradigm used in previous studies (Casler et al., 2009; Rakoczy et al., 2008; 2009). Building on the extensive literature documenting the developmental trajectory of artifact conceptualisation, drawing specifically on research supporting the explanatory framework of the design stance (Kelemen, 1999), the role of convention (Defeyter et al., 2007; Kalish & Sabbagh, 2007) and socio-cultural learning (Callanan et al., 2007; Tomasello, 1999; Vygotsky 1978) this study investigated two guiding questions: Do young children believe that artifacts embody their conventional function across all contexts rendering other plausible uses as completely wrong? - To what extent are there degrees of flexibility in how young children view the use of artifacts within specific contexts?

The results of the present study show an interesting pattern of responses relative to both questions. Children across both age groups intervened with implicit and explicit protest when Sally (the *test phase* puppet) used the objects in feasible atypical ways, replicating the findings of Casler and colleagues (2009). In the 'conventional-idiosyncratic' condition when Sally used the bottle for rolling play dough rather than using it for feeding the baby, 3- and 4-year-old children strongly objected. Their responses ranged from outright protest, ("No! It's not for that!"), to telling Sam about her ("Look! Look what she's doing"), they tried to teach her ("It's for the baby") or they simply laughed at, or scrutinised the silly and erroneous nature of Sally's actions. All of which suggest that they viewed Sally's atypical uses of the objects as mistakes.

However, normative protest was not only observed when conventional functions were violated but in *all* test phase conditions irrespective of the type of function demonstrated. So, when Sally used an object in the typical manner in the 'idiosyncratic-conventional' condition, children of both ages showed the same kind of spontaneous responses; "No! It's for rolling play dough!" and "Look what she's doing!" These results demonstrate that spontaneous protest occurred as a result of *any* second function, regardless of the manner in which the objects were used.

One explanation for this could be that the first function demonstrated served as the salient cue for how each object should be used in this context rather than being guided by conventionality or design as previous studies have discussed (German et al., 2007; Kelemen & Carey, 2007). This suggests that 'in this context' the first function operated like a rule in a game or in pretend play whereby '*X*' is assigned a status function which operates only within the immediate context (Rakoczy, 2007; Rakoczy et al., 2008; Tomasello, 1999;). In a game of football a jumper and a jacket

can serve as goal posts *in that context* only rather than function as items of clothing and through collective agreement the status function of these artifacts has changed. Consequently, in the present study, the first function demonstrated by Sam, seems to have provided the 'rule-to-follow' and was implicitly the 'right' way to use the objects 'in this context', any deviation from this rule, i.e., any function demonstrated by Sally, was seen as a violation by children across both age groups.

This is not to say that 3- and 4-year-olds were not sensitive to violations of conventional functions in the *demo phase*. On the contrary, in the 'idiosyncratic-conventional' condition where atypical functions were demonstrated by Sam first, children of both ages showed some normative protest towards violations of conventional use. This suggests that children do know that artifacts have a conventional function, after all most children use a toothbrush for cleaning their teeth every day and they see their parents and other people do likewise. Their experience tells them that toothbrushes are typically used for cleaning teeth, therefore, when the toothbrush was used in the *demo phase* for brushing the doll's hair some of the children intervened and protested at this atypical function. It could be argued that this demonstrated that young children believe there are right and wrong ways to use everyday artifacts like a toothbrush and further research is needed to clarify this issue (see Diesendruck et al., 2010). However, caution should be advised with this interpretation of the data and a closer examination of the results reveals the full picture.

First, not all children protested at the atypical functions demonstrated by Sam in the *demo phase*. On an individual level, only 4 (44%) children intervened in response to the idiosyncratic uses of the objects in this way. Some children's beliefs about how a toothbrush, for example, should typically be used were more strongly defined thus provoking an intervention. For others it was less so.

In contrast to the findings of Casler et al., (2009), young children did not view alternate uses of everyday objects as wrong *per se*. The interesting finding is that in the 'idiosyncratic-conventional' condition, although Sam's idiosyncratic uses provoked some degree of protest in some of the children, Sally's conventional uses in the *test phase* produced significantly more. Similarly in the 'instrumental-conventional' condition, no protest was demonstrated in the *demo phase* to instrumental functions whereas in the *test phase* when Sally used the objects in their conventional manner, children intervened significantly so. This demonstrates that the first function, irrespective of type of function, was a far more salient cue 'in this context' as the guide to how objects ought to be used.

Moreover, 92% of the children in this study, when asked what the item was for, the control question, answered overwhelmingly with the conventional function and did not encode any atypical use. These results showed that children understood the typical, everyday function of each artifact yet were able to show some flexibility regarding function in the context of the experimental paradigm.

Additionally, the explanation that children protested significantly more to the second function as a result of an implicit rule-governed context requires further explanation. At no point in the experimental paradigm were children told that they were going to

play a game. Following Sam's first demonstration, when asked "*would you like a turn*?" children could have inferred that they were playing a game. After all in most games involving two people, the structure usually involves the taking of 'turns' (Rakoczy, 2007). By imitating Sam's way of using the artifact when the child took their turn, the rule that '*this is how we use X in the context of C'* was primed (Rakoczy et al., 2009). This was demonstrated with interventions criticising Sally's behaviour after she announced she knew how to use the 'toothbrush' but then proceeded to use it in a totally different way to Sam and the child, i.e., the wrong way *in this context*. Sally entered into the rule-governed or first function-governed context but her actions violated the rules and as a result of this provoked interventions from children. A similar response could be provoked from players in the middle of a game of football if someone put on the jumper which was being used as one of the goal posts.

The data from the present study provides support for children's awareness of the normative structure of simple rule games. Further, the findings support the idea that function is viewed in relation to the specific context in which the artifact is being used along with the intentional goal of the user (Rakoczy et al., 2009; Tomasello, 1999; Callanan et al., 2007).

Strikingly, 3- and 4-year-olds understood the first function of each artifact as the normatively correct one *in this context*. However, because the implicit and explicit scores were collapsed into a sum protest score for each child, it is not clear to what extent all children responded with the same kind of normative interventions. The data suggests that the type of protest children demonstrated was varied across individuals and age groups. It would be important in future to compare different forms of protest; explicit normative protest, imperative protest and hints of protest across age groups along the same lines as Rakoczy, Brosche, Warneken & Tomasello, (2009). This would measure the degree to which children viewed the second function as a mistake and thus the context to be normatively structured.

Additionally, the demands placed on young children using this type of methodology should not be underestimated. Unlike a forced-choice paradigm task whereby children are given the choice of two answers to pick from, the action-protest paradigm relies on children's spontaneous interventions in an experimental setting with people who are unfamiliar to them. Consequently, for those children who never intervened, it is difficult to assess whether they viewed any of the functions as violations or not or if lack of articulation was due to shyness. Certainly the children who did spontaneously intervene with explicit protest were far chattier in the familiarisation phase than many of the other children.

Also, those children who intervened least in any of the conditions were older 4-year-olds from primary school rather than nursery school. This could reflect the change from child-centred play based activities into mainstream education whereby the emphasis, even in the foundation stages, is less on play and more on formal learning. Children could have thought it inappropriate to intervene in such an explicit manner.

Furthermore, the present study found no developmental trend between 3- and 4-year-olds who demonstrated similar levels of spontaneous behaviour within the action-protest paradigm. This suggests that 4-year-olds did not show greater sensitivity than 3-year-olds, regarding artifact function and both age groups were equally flexible when it came to any goal-directed uses of artifacts within this specific rule-governed context. Perhaps it is not surprising that little difference was found between 3- and 4-year-olds given that most of the children were from the same nursery groups and engage in the same kind of day-to-day activities. Artifact conceptualisation may be at a comparable stage developmentally, thus reflecting the similarity in responses. Future research should consider using children with a wider age gap of maybe two or three years as in previous studies (Defeyter et al., 2007; German & Johnson, 2002; Keil, 1989). This would potentially reflect any real developmental trend regarding how children reason about artifact function.

Consideration of how different contexts serve as cues to artifact use would be an important area of investigation in future research particularly in relation to who a child learns from. Whether that be parent to child, experimenter to child and child to child dyads or social learning by groups with respect to the developmental changes in children's flexibility and mutual exclusivity of artifact function (see Flynn & Whiten, 2010).

Further work is required to gain a deeper understanding of how children view typical and atypical uses of artifacts by adults and peers in different contexts. The findings in this study suggest that young children understand that everyday objects have a stable conventional function and at the same time they understand that atypical uses are not necessarily mistakes but perfectly feasible alternatives within specific contexts. Within this paradigm young children viewed artifact function as somewhat flexible providing support for previous studies which have shown that children under the ages of 6- and 7-years old demonstrate greater flexibility when viewing how an object can be used (Defeyter & German 2003; Defeyter et al., 2007; Siegel & Callanan, 2007).

In conclusion, this study suggests that the action-protest paradigm measured protest against the first function or rule provided thus children's protests had little to do with violations of convention or design. Far from viewing artifact functions normatively, young children were quick to learn that in certain contexts, which are rule-governed, artifacts can serve different purposes. Within rule-governed contexts such as games and pretend play, young children understand that everyday artifacts are assigned specific status functions which may deviate considerably from their conventional use.

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