The Influence of Question Wording on Children's Tendencies to Provide Teleological Explanations for Natural Phenomena

Jonathan Halls, Shaaron Ainsworth, and Mary Oliver
Email: ttxjh76@nottingham.ac.uk, shaaron.ainsworth@nottingham.ac.uk, mary.oliver@nottingham.ac.uk
Learning Sciences Research Institute, University of Nottingham

Abstract: Young children often provide teleological explanations for Entities and Phenomena in the natural world; stating, for example, that snow is for making snowmen or nighttime is for going to sleep. However, research supporting this stance has employed questions that could be considered to be teleologically-leading, suggesting a partially inaccurate view of children's tendency to provide teleological explanations. This paper compares a teleologically-leading treatment (*what is X for?*) with an open-treatment (*why is there X?*), finding that the leading-treatment resulted in significantly more teleological explanations that the open-treatment. This suggests children's proposed bias to provide teleological rationales about the natural world may be being overestimated.

Keywords: natural phenomena, science education, teleological reasoning, young children

Introduction

Teleological explanations are those that imply a natural object or phenomenon exists for a specific purpose (Kampourakis, 2014; Kelemen, 1999a, 1999b). In relation to science education about the Natural World the use of teleological explanations can be inappropriate and problematic as the focus is placed upon perceived outcomes or goals rather than causal accounts. Teleological reasoning is considered by some to be a major barrier to understanding evolution (Kampourakis, 2014) and a debilitating factor which restricts scientific reasoning (Hanke, 2004). However, there is an argument that the appropriateness of a teleological explanation depends upon the context in which it is used and the subject to which it relates. In these situations certain teleological accounts could be considered valuable learning heuristics (Ruse, 1989; Zohar & Ginossar, 1998).

Considering the appropriateness of a specific teleological explanation rests upon the type of teleology employed. The commonly discussed construct is design-teleology: that a topic has been designed or created for a specific purpose (Kelemen, 1999a, 1999b), if the creator was supernatural this could be considered to be religious-teleology. Teleology can also be conceptualised as functional-teleology, for example, appropriate functional explanations for Natural Organism appendages (Ayla, 1970), or as relational-teleology, a topic is not designed for something but rather subjectively used to do something (Ojalehto, Waxman, & Medin, 2013). While the type of teleology used is key to the appropriateness of the explanation, the focus of this paper is simply children's propensity to provide teleological rationales, regardless of their perceived relevance. In this paper these four constructs of teleology are collectively referred to as teleological explanations.

The levels of children's teleological thinking vary between ontological categories, due to the debate around if children are selective (provide teleological explanations for parts of Organisms and Artefacts) (Kampourakis, Palaiokrassa, Papadopoulou, Pavlidi, & Argyropoulou, 2012; Keil, 1994) or promiscuous (maintain a teleological stance for all ontological categories) (Kelemen, 1999a, 1999b) in their application of teleology. However, in some form teleological explanations dominate the scientific discourse of children age 4- to 9-years old, although their use decreases with age (Kampourakis, 2014; Kelemen, 1999b).

A key figure in this field is Kelemen. In an often-cited paper Kelemen (1999a) asked 4- and 5-year-old *what is X for?* in relation to several topics of Organisms, Natural Objects and Artefacts. The results indicated that the majority of children displayed a strong promiscuous tendency to provide teleological explanations for all ontological categories, with 57% teleological answers for Organisms, 88% for Organism parts 67% for Natural Objects, 58% for Natural Object parts, 65% for Artefacts and 80% for Artefact parts (means taken from graphs). However, there is a possibility that the question wording, *what is X for?* could be a teleologically-leading question, which may have inadvertently placed certain demand characteristics (Orne, 1962) upon the child leading them to provide a higher level of purposeful responses. This notion requires further investigation as the question wording used may have resulted in an overestimation of children's predisposition to provide teleological explanations.

Other studies have used different techniques to understand children's propensity for teleological reasoning. Kelemen (1999b) gave children in US Grades 1, 2 and 4 multiple choice questions (MCQ), for four Organisms and four Natural Objects, each containing a social or self-serving teleological and a scientific option.

Across the age range 70.5% of 1st Graders gave teleological responses for Natural Objects and 53.0% for Organisms parts; 2nd Graders responses were 75.0% for Natural Objects and 65.5% for Organisms; 4th Graders responses were 56.5% for Natural Objects and 59.5% for Organisms. However, dichotomous MCQ could be problematic as they may not measure what the respondent believes, merely which answer they think is more correct, or which option they dislike the least. This concern is shared by Kampourakis et al. (2012, p. 283) who maintain that the use of MCQ may not have provided a comprehensive view of children's actual beliefs. To explore this they used similar methods to Kelemen (1999b) but instead of MCQ, used open-ended questions on a written survey. Their findings support a selective application of teleology, not a promiscuous application; Natural objects traits received 17.2% teleological responses for Pre-schoolers, 9.0% for 1st Graders and 4.7% for 2nd Graders. Organism traits received 27.4% teleological responses for Pre-schoolers, 26.68% for first graders and 21.48% for Second graders. The difference in levels of teleological answers in the studies by Kelemen and Kampourakis et al. suggests that assessment method, MCQ or open-ended questions, could influence children's tendency to choose or provide teleological explanations. Although this finding is only relevant to Natural Objects, Organisms received similar levels of teleological answers in both papers, perhaps because functional rationales could be used to explain the appendages of Organisms. Therefore, questions investigating organism parts could be leading, as a functional-teleological explanation is a plausible and scientifically acceptable response.

It should be noted that Kelemen (1999a) is not the only researcher to use what could be considered questions that lead to, or require, a teleological answer. Keil (1994) used MCQ options in the form of *X helps Y* and *it is better for X to have Y.* Other abstracted examples of open-ended and MCQ include, *why do these X's do Y?* (Polling & Evans, 2002), *why does Y have X?* (Kampourakis et al., 2012), *why do you think X had Y?* (Kelemen, 1999b). The latter two question stems being particularly difficult to answer for Organism appendages without using functional-teleology (e.g. an eagle's wing can be considered to be for flight). These possible leading-questions share a similar stem, either the question is asking for the purpose of a certain topic (X), or for the purpose of an appendage (X) of a certain topic (Y). These two questions stems, *What is the purpose of X* and *What is the purpose of X for Y* can be further combined into *what is the purpose of X,* or simply *what is X for?* This generalised question stem, of what may possibly be a teleologically-leading question, is the same as the one used by Kelemen (1999a). Therefore, it provides a suitable example of a leading-treatment.

The purpose of this study was to investigate the hypothesis that question wording influences children's responses to questions about scientific phenomena, with a leading treatment (*what is X for?*) predicted to result in more teleological responses than an open treatment (*why is there X?*). Furthermore, it was hypothesised that as children's age increased the levels of scientific responses would increase, however it was not clear how age would interact with question format.

Method

Participants

The participants were 66 primary school children, aged 68- to 104-months-old (5- to 8-years-old) (M = 85.59, SD = 10.84, Female = 34). Participants were equally split between Year 1, 2 and 3, no child was considered to have English as an Additional Language or Special Educational Needs.

Procedure

The study used a repeated-measures design, the two levels of the question wording variable were the leading-treatment (*what is X for?*) and the open-treatment (*why is there X?*). Children received five of each question format across ten topics of Natural Phenomena. Piloting was conducted to find appropriate topics which children recognised and could articulate a response. The topics used, following piloting, were: Day, Darkness, Light, Night, Rain, Rainbows, Storms, Snow, Waterfalls and Waves. The topics were fully counterbalanced across treatment type to avoid influencing the main variable. Children were randomly assigned to treatment groups (leading-treatment 1st or open-treatment 1st).

Children took part in structured individual interviews, in a shared space outside of the main classrooms. All interviews began with a short drawing to settle the child and act as an icebreaker. Following this, participants received either their five leading-questions or open-questions, depending upon treatment group. If a response was unclear the probe *can you tell me a bit for about Q?* (Q being the unclear statement) was used to elicit more information. If a child declined to answer, or suggested they did not know, the interviewer moved to the next question. After the first set of questions the participant played another round of the drawing game, before completing the interview with the remaining five leading- or open-questions.

Measures

To investigate the influence of question wording children's explanations were transcribed and coded as either a teleological or a scientific response; answers consisting of non-sequiturs, descriptions and 'don't know' responses were removed for analysis. The coding rubric is outlined in Table 1. A tenth of the data, 66 responses, were coded by a second coder, calculation of Cohen's K (K = .885, $p < .001$) revealed a high level of agreement.

Table 1: Coding rubric for categorising explanation type

Type of response (score)	Explanation	Example
Teleological explanation (0)	The existence of the topic is referred to by invoking a purpose, implying that the topic aids another entity	Night is "for making the sky dark so we can have a little sleep" Rain "is for keeping all the plants, grass and flowers healthy"
Scientific explanation (1)	The existence of the topic is explained via a, simplified, causal explanation. However, does not have to be scientifically correct. The topic is not imbued with purpose	"when it rains and suns at the same time it makes, it makes a rainbow" When "it's very cold the rain comes down and it freezes and becomes snow"
Other (uncoded)	Non-sequiturs, descriptive answers, 'don't know' and non-responses	"my favourite rainbow colour is red" "when it's stormy the floor gets wet"

Results

Across the two treatments, 72 out of 660 responses were coded as 'other', 456 (69.0%) were coded as teleological answers and 132 (20.0%) as scientific. Removing the 'other' data resulted in a split of 77.6% teleological answers and 22.4% scientific responses. Separating the data by question wording suggests a strong influence of question wording, with 92.12% of the leading-treatment's responses being teleological answers compared to 68.18% teleological explanations for the open-treatment.

A two-way ANCOVA was conducted, with the independent variable of question wording (leading- and open-treatment), and the dependent variable of summed scores for the five leading-questions and five open-questions. Teleological responses scored 0 and scientific answers scored 1; therefore, each treatment has a possible summed score of 0-5. The covariate was mean-centred age in months. Means are displayed in Table 2.

Table 2: Table mean scientific responses by treatment type

	Total (n = 66)	Leading-treatment 1st (n = 33)	Open-treatment 1st (n = 33)
Treatment	Mean score as % of scientific responses (*SD*)	Mean score as % of scientific responses (*SD*)	Mean score as % of scientific responses (*SD*)
Leading-treatment	7.88 (13.979)	7.88 (15.763)	7.88 (12.185)
Open-treatment	31.82 (30.377)	26.06 (26.685)	37.56 (33.074)

The ANCOVA showed a significant effect of question wording upon response type, F (1, 63) = 44.579, $p. < .001$, $\eta^2 = .414$, with the leading-treatment resulting in a significantly larger number of teleological responses than the open-treatment. The covariate of age in months was a significant predictor of response type F (1, 63) = 4.402, $p. < .040$, $\eta^2 = .065$ but did not interact with question wording, F (1,63) = 0.013, $p. > .05$, $\eta^2 < .001$, confirming that, regardless of treatment type, children provided less teleological explanations with age. Checks on the counterbalancing confirmed there was no significant influence of treatment order F (1, 63) = 4.402, $p. > .05$, $\eta^2 = .065$ upon participant score, so randomisation was successful. Furthermore, there was no interaction between treatment order and question wording, F (1, 63) = 2.592, $p. > .05$, $\eta^2 = .040$. When receiving the leading-treatment first, children were not primed to provide teleological explanations for their second set of questions using the open-treatment, nor when receiving the open-treatment first were children primed to provide scientific answers.

Conclusion and implications

The results confirm that children (aged 5- to 7-years-old) have a strong teleological bias to provide purposeful explanations for Natural Phenomena. With regards to this debate around if children employ promiscuous- or

selective-teleology these results supports the former. When receiving the open-treatment 68.18% of children's explanations were teleological answers, a score similar to the findings of Kelemen (1999b), 56.5-75.0% for Natural Objects, than to those of (Kampourakis et al., 2012), 4.7-17.2 %. However, it should be noted that this study is limited by only investigating topics of Natural Phenomena.

In relation to the influence of question wording, the results confirm the hypothesis: the leading-treatment (*what is X for?*) resulted in children giving predominantly teleological answers and the open-treatment (*why is there X?*) provided less teleological and more scientific responses. Consequently, research employing leading-question may have inadvertently placed demand characteristics upon their participants, leading to a higher level of teleological explanations. This result does not undermine the findings of Kelemen (1999a), and others cited above. However, it does suggest an overestimation of children's teleological tendencies; indicating that children may be more scientifically competent in their explanations than the literature suggests. Further research would be needed to ascertain the influence of question wording for different ontological categories, although this may be problematic with Organisms or Appendages where functional-teleological explanations could be considered appropriate. While children's tendency to provide teleological explanations decreased with age, supporting Kelemen's (1999b) and (Kampourakis et al., 2012) findings, the influence of question wording did not diminish: all ages were equally influence by treatment type. Therefore, the finding that question wording can result in an overestimation of teleological tendencies may be applicable to a wider age-range.

The main implication arising from this study is the need for research assessing children's teleological or scientific explanations to avoid the use of teleologically-leading questions. However, an educational implication would be that if young children advocate less teleological explanations for Natural Phenomena that previously indicated, they may be more susceptible to the teaching of causal accounts. This conclusion forms part of a larger research project which investigates how question topics within the same ontological category affect children's responses. It also analyses the type of teleological explanations to examine why children may be providing purposeful rationales. For example, are children using teleology to appropriately explain a function (functional-teleology), to suggest a topic has been designed for a purpose (design-teleology) or to propose a purpose for which a topic could be used (relational-teleology). While analysis is ongoing, initial results suggest that selection of topic and disregard for the type of teleology children are advocating may also lead to an overestimation of children's teleological tendencies.

References

Ayla, F.J. (1970). Teleological explanations in evolutionary biology. *Philosophy of Science, 37*(1), 1-15.

Hanke, D. (2004). Teleology: The explanation that bedevils biology. In J. Cornwell (Ed.), *Explanations: Styles of explanation in science*. Oxford: Oxford University Press.

Kampourakis, K. (2014). *Understanding evolution*. Cambridge: Cambridge University Press.

Kampourakis, K., Palaiokrassa, E., Papadopoulou, M., Pavlidi, V., & Argyropoulou, M. (2012). Children's intuitive teleology: Shifting the focus of evolution education research. *Evolution: Education & Outreach, 5*, 279-291.

Keil, F.C. (1994). The birth and nurturance of concepts by domains: The origins of concepts of living things. In L. A. Hirschfeld & S. A. Gelman (Eds.), *Mapping the mind: Domain specificity in cognition and culture* (pp. 234-254). Cambridge: Cambridge University Press.

Kelemen, D. (1999a). The scope of teleological thinking in preschool children. *Cognition, 70*(3), 241-272.

Kelemen, D. (1999b). Why are rocks pointy? Children's preference for teleological explanations of the natural world. *Developmental Psychology, 35*(6), 1440-1452.

Ojalehto, B., Waxman, S.R., & Medin, D.L. (2013). Teleological reasoning about nature: Intentional design or relational perspectives? *Trends in Cognitive Sciences, 17*(4), 166-171.

Orne, M.T. (1962). On the social psychology of the psychological experiment: With particular reference to demand characteristics and their implications. *American Psychologist, 17*, 776-783.

Polling, D.A., & Evans, E.M. (2002). Why do birds of a feather flock together? Developmental change in the use of multiple explanations: Intention, teleology and essentialism. *British Journal of Developmental Psychology, 20*(1), 89-112.

Ruse, M. (1989). Teleology in biology: Is it a cause for concern? *TREE, 4*(2), 51-54.

Zohar, A., & Ginossar, S. (1998). Lifting the taboo regarding teleological and anthropomorphism in biology education - heretical suggestions. *Science Education, 82*, 679-697.

Acknowledgments

This project is funded by the Economic and Social Research Council (ESRC) [grant number 13366484].