Title
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How Many People Know? Representing the Distribution of Knowledge

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Abstract

The representation of the distribution of knowledge guides information gathering, help seeking, and communication. The research aimed to explore adults' and 4-year-olds' representation of the distribution of common (conventional and procedural) knowledge and expert knowledge associated with five occupations in their community. In addition, we examined estimates of occupation-related everyday (non-expert) knowledge. Both groups estimated that common knowledge is more widely held than expert knowledge, with everyday knowledge in between. For adults, but not children, the distribution of expert knowledge was correlated with estimates of the proportion of people in each occupation.

Keywords: knowledge distribution; expertise; children; development

Introduction

People act competently and adaptively in their physical and social surroundings. Yet, their understanding of the physical and social worlds is staggeringly shallow. The solution of this paradox likely rests in the social embedding of human behavior: we rely on each other to fill the holes in our understanding (Keil, 2003). Understanding who knows what and how knowledge is structured is thus a critical aspect of human social cognition. Equally important, though less well understood, is understanding the distribution of knowledge in the population. Distinguishing widely distributed from narrowly distributed knowledge could affect both the selectivity of our interpersonal interactions and the structure of our social networks.

Knowledge is clearly unevenly distributed. Some knowledge, such as conventional knowledge of common object labels and functions, is shared by all members of a community. Similarly, some experientially derived knowledge, e.g., that grass is green, can be expected to be known by all in virtue of shared bodily experience. In contrast to this "common knowledge," other knowledge is privy to only groups of people within the community. The division of labor that characterizes most modern communities leads to concentration of different expertise in different people.

Surprisingly, the question of the relative spread of different kinds of knowledge has received little attention. Most of the literature on expertise has focused on explaining the attainment of expertise in various domains of activity (Feltovich, Ford, & Hoffman, 1997) and on understanding of the clustering of knowledge in different kinds of experts (Danovitch & Keil, 2004; Keil, Stein, Webb, Billings, & Rozenblit, 2008). For instance, preschoolers appear to recognize that expertise is topic-specific and that being an expert in one domain does not entail being an expert in other domains (Koenig & Jaswal, 2011). Furthermore, by age 5, children appear to be able to link their skeletal understanding of knowledge domains (psychology, physics, biology) with how knowledge is clustered in individual minds. That is, they can make an inference from what a person knows to what other things the person is likely to know (Keil et al., 2008).

With respect to the spread of knowledge, previous research on children's understanding of expertise provides evidence exclusively for the existence of understanding of non-overlaps in knowledge. For instance, Lutz and Keil (2002) presented 3- to 5-year-old children with a list of items representing the expertise of doctors and car mechanics. Children were asked questions like "Who would know more about how to fix a broken arm?" While children identified above chance the relevant expert, this suggests sensitivity to non-overlaps in knowledge and that not everyone knows a given item. The data do not speak to the question of whether children recognize that expert knowledge is relatively narrowly distributed in the population.

Similar issues arise with other studies that have addressed children' understanding of differences in knowledge. For instance, a number of studies address children's understanding of the difference between child and adult knowledge (Aguiar, Stoess, & Taylor, 2012; Fitneva, 2010; Fitneva, Ho, & Hatayama, 2016; Taylor, Cartwright, & Bowden, 1991; VanderBorght & Jaswal, 2009). Nevertheless, these studies only reveal that children identify non-overlaps of knowledge between social groups. They don't address children's representation of the size of social groups and therefore fail to capture children's representation of the spread of different kinds of knowledge. Perhaps the only study that allows such an inference, Burton and Mitchell (2003) showed that by age 7, children limited private knowledge to the self and denied its possession by a range of adults and children.

The question of children's representation of the distribution of knowledge has been also examined for conventional knowledge such as word meaning (Graham, Stock, & Henderson, 2006; Henderson, Weighall, Brown, & Gaskell, 2013). The dominant method here involves examining whether children extend novel conventional knowledge (e.g., of an object label or a game rule) to a new person. Although the young children in these studies appear to appropriately extend conventional knowledge to others but restrict idiosyncratic knowledge such as desires to individuals, it is not clear that they see conventional knowledge as widely distributed. The reason is that in these studies, new individuals are generally not introduced as randomly sampled from the population.

Recent evidence does suggest, however, that children are sensitive to indices about the spread of knowledge. For examples, Cimpian and Scott (2012) tested the beliefs of 4 to 7 year olds on how many people would know generic and non-generic facts. Children associated generic facts with "many" and non-generic facts with "few" people. Presumably this performance implies that children assume that generic information concerns how the world works and see adults as experts about the world (Cimpian & Scott, 2012).

The question of how knowledge is distributed in the population highlights the social embeddedness of expertise. Experts function within a community. The division of labor – in many cases the motivator for the development of expertise – would not be feasible and workable if it were not for the social relations allowing for exchange of goods, services, and ideas. Communicating and interacting with various experts both rests upon and develops relevant knowledge. This knowledge is neither conventional nor shared in the same way perception of color is. In contrast to conventional and common experiential knowledge, it can show considerable individual differences based on experience with the problem domains and/or access to experts. We call this knowledge "everyday knowledge."

To sum up the goal of this study was to examine young children's understanding of the distribution of expert, everyday, and conventional knowledge. In particular, we had three questions: 1) Do children associate expert knowledge with a smaller proportion of the population than common knowledge? 2) Do they associate it with a smaller proportion of the population than everyday knowledge? 3) Is the perceived distribution of expert knowledge related to the perception of number of experts in the community?

Even though past research has documented that by age four children understand that the knowledge of adult experts is not co-extensive (Lutz & Keil, 2002), they may nevertheless associate expert knowledge with large portions of the population and not recognize that expert knowledge is more narrowly distributed than common and everyday knowledge. This would be consistent with children seeing adults as omniscient (Piaget, 1959), or at least people capable of exceptional performance in more than one domain. Alternatively, we expected that even 4-year-olds might associate expert knowledge with a smaller portion of the population than everyday and common knowledge. This is because even very young Canadian children have first hand contact with experts (e.g., doctors) and observe the exchange of goods, services, and ideas ensuing from the division of labor.

There are a number of ways in which people can develop understanding of the spread of expertise. One of them is keeping track of the people they encounter in different occupations. If this is the case, participants' estimates of the proportions of experts among adults would correlate with their estimates of the proportion of people with expert knowledge. Thus, the study included questions asking participants to estimate the prevalence of different occupations in their community.

The study included adults and 4-year-old children who are among the youngest to demonstrate recognition of non-overlaps in the knowledge of adults (Lutz & Keil, 2002). At this age, children are also sensitive to relative magnitude.

Method

Participants

Thirty-six 4-year-old children and 18 adults participated in the study. The children lived in the mid-size urban community of Kingston, Ontario and the adults were students at Queen's University in the same city. Six children were excluded due to not completing the study (2), self-professed silly attitude (1) and clear pattern in responding (i.e., going up / down the scale, 3). Thus the final sample included 30 children (average age 54 months, range 48-60; 19 girls, 11 boys).

Materials

We asked participants to indicate their perception of the distribution of expert knowledge, everyday knowledge in the same domains, and common knowledge. The expert knowledge pertained to five occupations: farmers, builders, pilots, car mechanics, and doctors. These occupations include the ones frequently appearing in the literature and vary in frequency in the community (more builders, car mechanics and doctors relative to farmers and pilots). An example of an *expert knowledge* question is "How many grown-ups know how to fix a broken arm?". The corresponding *everyday knowledge* question was "How many grown-ups know how to take their temperature?"

The five *common knowledge* items referred to conventional knowledge, e.g., "How many grown-ups know how to use a fork?" and procedural knowledge, e g., "How many grown-ups know how to lock their front door?" To examine whether the reported spread of expert knowledge corresponded to participants' perceived number of experts in the community, we also asked an *occupation-focused question* in each domain, e.g., "How many grown-ups in Kingston are doctors?" Participants were also presented with 12 questions about the distribution of various individual characteristics and behaviors, e.g., "How many grown ups in Kingston go to work / have pets?" These *property questions* aimed to further prompt thinking about wider and narrower sets of the population.

Children answered the questions on a 5-point scale with a slider. The five points depicted with pie charts 0%, 25%, 50%, 75%, and 100% of the population. Note that this scale was not designed for recording realistic estimates of prevalence. This would have required a logarithmic scale and we were not aware of evidence of successful use of such a scale with children.

For the adults, the questions were presented on a piece of paper. The instructions and a figure representing a 0-100 scale with the pie charts used with the slider appeared on top of the page.

Procedure

Adults Adult participants answered the questions by writing down their answers next to each question. They were free to answer the questions with any number they wished in the 0-100 range. Adults received course credit for participating.

Children The experiment began by explaining to children that they will be asked questions about grown-ups. After that, the experimenter informed them that they were to answer the questions by moving the slider to the pie chart that showed the relevant proportion of grown-ups who know. As a warm-up, children were asked to position the slider in the all, none, and half positions. Children were also asked "How many grown ups in Kingston are shorter/taller than you?" to provide practice answering with the slider.

Children were asked the experimental questions in the same random order, with the property questions interspersed among them. Although children were free to position the slider anywhere on the 0-100 scale, they used the five points, consistent with the directions they received.

Subsequently, children were asked whether or not their parents knew the items, e.g., "Do mom and dad know how to fix a broken arm?" These questions aimed to provide an assessment of whether children encountered the relevant information in their homes. The study included several additional questions the data from which have not yet been analyzed. These questions were presented later and do not affect the current results. Parents also answered questions regarding their child's familiarity with a large set of occupations.

Results

Figures 1 and 2 show respectively adults' and children's responses to the questions about adults in the occupations of builder, car mechanic, doctor, farmer, and pilot, and related expert and everyday knowledge. In addition, they show the groups' estimates of the prevalence of common knowledge.

The research questions identify two key comparisons in the data: expert – common knowledge and expert – everyday knowledge. In addition, we examined the correspondence between participants' estimates of the proportion of people in the five occupations and the distribution of expert knowledge related to these occupations in the population. Thus, the analytical approach included a combination of targeted t-tests and analyses of variance and correlation.

Adults

As Figure 1 suggests, on average, adults associated expert knowledge with a significantly smaller proportion of the population than common knowledge (M_{expert} = 9.93; M_{common} = 92.16; $t(17) = 36.36$, $p < .001$).

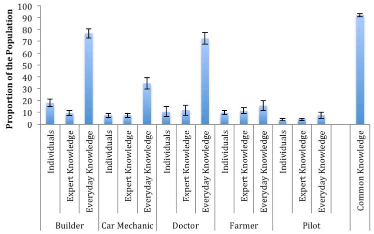

Figure 1. Adults' estimates of the proportion of the population in five occupations and of the distribution of related expert and everyday knowledge. Adults' estimate of the distribution of common knowledge appears on the right. Error bars represent ± 1 SE.

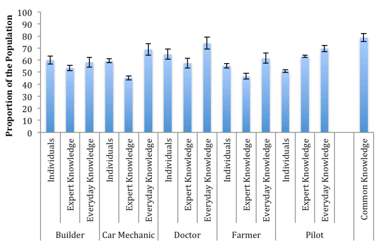

Figure 2. Children's estimates of the proportion of the population in five occupations and of the distribution of related expert and everyday knowledge. Children's estimate of the distribution of common knowledge appears on the right. Error bars represent ± 1 SE.

We conducted an area (5) x question (occupation-focused, expert knowledge, everyday knowledge) repeated measures ANOVA to assess the differences in adults' assessments of the prevalence of the five occupations, expert knowledge, and everyday knowledge. Both main effects and the interaction effect were significant. The effect of area ($F(4, 68) = 42.7$, $p < .01$) reflected that some occupations and related knowledge were perceived as more common in the community than others. Of key interest, was the effect of question, $F(2, 34) = 138.2$, $p < .01$. As Figure 1 suggests, there was a significant difference in the estimates of the distribution of expert and everyday knowledge (M_{expert} = 9.93; $M_{everyday}$ = 41.42; $t(17) = 11.66$, $p < .001$). Furthermore, there was no difference in participants' responses to the occupation and expert knowledge questions, $t(17) = 1.08$, $p = 0.295$. Given the significant interaction effect between area and question ($F(8, 136) = 47.7$, $p < .01$), we conducted two follow-up analyses. First, we examined the difference between expert and everyday knowledge items in each area. Although always in the expected direction, this difference was significant in three of the five areas (the exception being farmer and pilot).

Second, as we were interested in the relationship between participants' perceptions of the proportion of professionals and of the distribution of expert knowledge, we calculated the correlation between these variables (rather than their difference). The correlations ranged from .45 to .89 (p's ≥ .06) suggesting an overall significant relation between these variables.

In sum, adults recognized that expert knowledge is less prevalent than common knowledge. Furthermore, their estimates of the distribution of expert knowledge was tightly linked to their beliefs about the proportion of people in each occupation.

Children

As Figure 2 suggests, 4-year-olds associated the common knowledge items on average with 79% of the population, which was significantly larger than their estimate of the prevalence of expert knowledge 53%, $t(29) = 5.1$, $p < 0.01$.

As for the adults, we conducted an area (5) x question (professional, expert knowledge, everyday knowledge) repeated measures ANOVA on children's responses to the questions about the distribution of expert and everyday knowledge and occupations. The analysis only showed a significant effect of question type, $F(2, 58) = 6.2$, $p < .01$. Children associated expert knowledge with a significantly smaller proportion of the population than everyday knowledge (M_{expert} = 53; $M_{everyday}$ = 67; $t(29) = 3.61$, $p < .01$). The difference in children's estimates of the number of professionals in the population and the distribution of expert knowledge was not significant, $t(29) = 1.35$, $p = 0.19$. The correlations between children's answers to these two questions in the individual areas ranged between .3 and .45 and with the exception of highest (for farmer domain) failed to reach significance.

Interestingly, children's estimate of the proportion of people in the five occupations was on average of 58%. It was higher than their estimate of the proportion of people with related expert knowledge (53%) but lower than their estimate of the distribution of everyday knowledge (67%).

The next analysis examined 4-year-old's responses to the questions regarding their parents' knowledge. Children's answers were averaged across area. Common knowledge was attributed to parents on average 90%, significantly more often than either expert or everyday knowledge (both t's < .01). Everyday knowledge was more likely to be attributed to parents than expert knowledge (M_{expert} = 35; $M_{everyday}$ = 64; $t(29) = 4.86$, $p < .01$). The difference between expert and everyday knowledge was significant for all areas except car mechanic.

Discussion

The present findings enrich our understanding of children's and adults' representation of the spread of different kinds of knowledge. Adults showed clear differentiation between expert knowledge and related everyday knowledge as well as between expert knowledge and common knowledge. Furthermore, their estimates of the distribution of expert knowledge closely corresponded to their estimates of the frequency of different occupations. Children also indicated that expert knowledge is less widely distributed than everyday knowledge and common knowledge. Past research has revealed that children recognize that different adults know different things (Keil et al., 2008; Lutz & Keil, 2002). The current study extends these findings to demonstrate that both children and adults see differences in the spread of different kinds of knowledge.

It is important to note that children's responses in the present study are unlikely to be affected by generic language that distinguishes knowledge that most people have from idiosyncratic knowledge of individuals. As mentioned, children can use generic language to distinguish widely and narrowly known novel facts (Cimpian & Scott, 2012). Generic language did not distinguish the stimuli in the different conditions in present study. Thus, 4-year-olds not only judge widely and narrowly held knowledge based on linguistic cues but have built representations of how knowledge in their environment varies in its spread.

How do people arrive at these representations, especially with regards to expert knowledge? One possible route to representing the spread of expert knowledge is through considering the frequency of different occupations. Indeed, there was a clear relationship between adults' estimates of the proportion of people with the target occupations and the proportion of people with occupation-related knowledge.

However, no such relationship was evident in the children's data. In fact, children's estimates of the frequency of different occupations were in-between the spread of expert and everyday knowledge. This finding suggests that children may not arrive at a representation of the distribution of knowledge considering the frequency of experts. It is possible that children's estimates of the distribution of expert knowledge and people in related occupations derive from different sources. Naturally, the occupation questions focused on social actors while the expert knowledge questions focused on mental states associated with activities. For young children, tracking activities may be easier (given that their estimates were lower and thus more realistic) than the social agents associated with those activities.

Another route children can take to developing understanding of whether something is widely or narrowly known is through observations of adults in the family. Indeed, the analyses revealed that children crisply differentiated expert, everyday, and common knowledge when asked whether their parents have that knowledge.

Children appear to believe that the number of people in each of the five occupations targeted by the study is over

50%. This conflicts with a number of assumptions adults make about expertise, e.g., that a person does not have an opportunity to develop professional expertise in many areas, but is consistent with findings suggesting that children extend expertise to other domains (Taylor et al., 1991). It may not be warranted, however, to make much of the absolute value of these numbers. First, children may have very well been providing relative answers (e.g., "many" vs. "few") and, second, the scale was not conducive to capturing realistic estimates of the small proportion of the population in the target professions. It will be useful to explore in future research whether children can work with a logarithmic scale.

On the flip side, even though high, children's estimate of the number of people in different occupations suggests that they realize that not everyone has the same profession (only half do!). In other words, although they may consider adults to be well rounded, they do not consider them omniscient.

Clearly, the present conclusions are limited by the occupations that were represented and the associated items chosen for the study. As the analyses suggested, the magnitude of the difference between expert and everyday knowledge varied substantially across areas. The domains were intentionally chosen to vary in the representation of the different occupations in the community. This could have affected the results, as the low frequency of pilots and farmers could have led to floor effects in the answers to both knowledge questions. It is also possible that the variability by area is due to the particular items chosen for the study. Nevertheless, even though the effect sizes varied across occupation for both age groups, their direction was consistent.

In conclusion, the present study is one of the first to provide clear evidence pertaining to adults' and children's beliefs about the relative spread of common, expert, and everyday knowledge. Even 4-year-olds discriminated between what everyone in their community is likely to know and expert knowledge, i.e., knowledge obtained through extensive experience and training. These findings complement our current understanding of people's representation of the clustering of knowledge (Danovitch & Keil, 2004; Keil et al., 2008) and help build a comprehensive picture of the social landscape in people's minds which supports adaptive behavior in the face of incomplete knowledge.

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