Research Article

The Influence of Exposure to Scientific Knowledge on Intuitive Knowledge of Sound: In Relation to Material Properties

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Abstract

The present study aimed to examine how intuitive knowledge of sound changed by exposure to scientific knowledge in terms of attribution of material properties to sound. Participants were 70 5th graders, 25 university literature majors, and 28 physics majors. Substantiality and weight were selected as material properties and two questions for each property, four in total, were generated to examine whether they were attributed to sound. Participants were asked to choose one option from among several items and write the reasons for their choice. According to the results of analyses of their descriptions, most of the children consistently attributed substantiality or weight to sound in the two questions on each property, while most of the university students attributed them in one of the two questions. These results suggest that there was a tendency to consider sound as a kind of material in all three groups, though not equal in the degree of consistency. For the questions on substantiality, answers based on intuitive knowledge decreased while those based on scientific knowledge increased in the order of 5th graders, literature majors, and physics majors. For the questions on weight, however, the same pattern was observed in the answers based on intuitive knowledge, while those based on scientific knowledge did not increase. In particular, only one physics major consistently answered in the scientifically correct way, which was fewer than literature majors. These results indicate that incorrect intuitive knowledge of sound was gradually revised to be more relevant to scientific knowledge, though the property of weight was more difficult to dissociate from sound than substantiality.

Key words: Sound, Intuitive knowledge, Scientific knowledge, Formal learning

I. Introduction: background and aims of the present study

For the past three decades, researchers in cognitive development have focused on children’s and adults’ conceptions and misconceptions of various physical phenomena: Newtonian mechanics (Clement, 1982; McCloskey, 1983), electricity (Cohen, Eylon and Daniel, 1983), and geometric optics (Galili and Hazan, 2000). Most of these studies commonly reported that understanding scientific knowledge is not easy, not only for children but also for adults. One of the reasons for this difficulty is that people often form scientifically incorrect intuitive knowledge through a variety of experiences before formal learning. According to Chi and Roscoe (2002), this knowledge is repeatedly used in everyday life because of its usefulness, so that it becomes robust and resistant to change. Therefore, when it is inconsistent with scientific knowledge, their intuitive knowledge may impede their understanding of scientific knowledge.

In the present study, sound was selected from the many domains of science taught at school, mainly for the following two reasons. First, only a few researchers have studied learners’ conceptions of sound, and there seem to be insufficient findings for developing an instructional method. The second reason is that in Japan, we first formally learn about sound at the age of 12–13, although we experience some phenomena related to sound before birth (Parnicutt, 2006). Thus it takes a very long time before scientific knowledge of sound is taught to students. This considerable period of time would make informal conceptions of sound quite robust and resistant to change.

Previous studies showed that university graduates and undergraduates majoring in physics tended to consider sound as a kind of object (Linder, 1993; Linder and Erickson, 1989). In Linder and Erickson’s (1989) study, tertiary physics students were interviewed and asked...
several questions related to everyday and hypothetical sound phenomena. They explained the sound propagation process as if it were a kind of object. For example, they answered that space was necessary for sound propagation, and thus a sound did not propagate easily through objects with high density because they had less space. And, as another example, they considered sound velocity to be affected by its loudness because a sound with high volume had more weight than one with low volume.

Responding to Linder and Erickson's study, Masens and Lautrey (2003) examined children's conception of sound. They focused on three properties of material: substantiality, weight, and permanence. An object that has substantiality means that it is not an imaginary but a real thing, built solidly, and has strength or hardness to some extent. An object that has weight means that it is gravity-sensitive. The property of permanence means that an object does not disappear without any external force. In their study, 6, 8, and 10-year-old children were given three situations of sound corresponding to each property. In the substantiality task, in which an alarm clock was put into a box, they were asked to answer whether its sound could be heard and why they thought so. The situation of the weight task was that a younger child said to the participant that an alarm clock became a little bit lighter than when it was ringing. Participants were asked to answer whether the younger child was correct or not and to explain the reason for their answer. In the permanence task, participants were asked to give the range in which sound could travel from a loudspeaker placed in the center of the classroom. According to the result, Mazens and Lautrey concluded that children gradually ceased to attribute properties of material to sound without formal learning, but about half of 10-year-old children still considered it as a kind of object. Furthermore, Lautrey and Mazens' (2004) study, in which 8-year-old children were given the same tasks, suggested the probability that permanence was the first property to be excluded from sound, followed by weight, and finally, substantiality.

According to previous studies, there is a tendency to consider sound as a kind of object in both children before formal learning and in university physics majors, which would indicate that to achieve a deep understanding of sound is quite difficult. However, it is still unclear how similar university students' conceptions of sound are compared to children's, because they were given different tasks in different ways. Thus, the present study aimed to directly compare conceptions of sound of 5th-graders before formal learning to those of university literature and physics majors, using the same tasks for each group. University literature majors were selected because they had been taught sound at junior high school and had not studied it since, and thus their understanding of sound would more accurately reflect everyday experience than that of physics majors. Also, a comparison of 5th graders, university literature majors, and university physics majors should make it possible to examine how the intuitive knowledge of sound would change by exposure to scientific knowledge. We focused on substantiality and weight, not permanence, because most children of as little as 8 years old did not attribute it to sound in Lautrey and Mazens (2004). Although the present study referred in some way to tasks used in the previous studies, Linder and Erickson's questions were not used since they seemed too specialist and difficult for children and university literature majors. Mazens and Lautrey's (2003) tasks were revised or discarded to make them more appropriate for both children and university students. Several tasks were newly generated through discussion by the authors to examine the two properties. Regarding methodology, previous studies collected data by interview, but we used a paper-and-pencil style since the elementary school did not permit individual interviews.

II. Method

1) Participants

The participants were 70 public elementary school 5th graders (mean age 10.8, range 10–11, 36 males and 34 females), 25 private university students on literature courses (mean age 20.2, range 18–24, 12 males and 13 females), and 28 national university students on physics courses (mean age 22.4, range 21–25, all male). The university literary students were attending an undergraduate school of humanities or law. Nine out of 25 had learned physics during high school, and the others had selected biology or chemistry. All the university physics students were at-
tending an undergraduate school of engineering science and had experienced physics classes during high school.

2) Materials

Two questions for each property of object, substantiality, and weight were generated by the authors considering the tasks used in previous studies. Participants were asked to answer each question in which physical phenomena related to sound were shown in everyday contexts or in experimental or hypothetical contexts (see appendix).

2.1) Substantiality

One question for substantiality included a phenomenon whereby a sound passes through different types of solid structure: paper, wood, and iron (Question 1). The participants were asked: “Here are three boxes, each of which is made either of paper, wood, or iron. When an alarm clock is put into these boxes, and then chimes, is it possible to hear the sound of the alarm clock from each box? From which box can the loudest sound be heard?” The other question involved the phenomenon whereby sound passes through a wall with different sized holes. Participants were asked to answer from which wall the sound with higher volume could be heard (Question 2). Both questions were related to the fact that sound can pass through a solid structure because it does not have any substance but is a vibratory process. That is, a space to pass through is not essential for sound propagation. So, for example, when a participant’s explanation was based on the fact that there was no space for sound to pass through, he or she was regarded as attributing substantiality to sound. Information such as the thickness of the boxes and walls, and the loudness of the sound was not given, in order to examine whether the participants refer to the sound’s hardness or strength as observed in Mazens and Lautrey (2003).

2.2) Weight

One question for weight concerned the relationship between weight and loudness or clarity (Question 3). Participants were asked “In one situation, there is a loudspeaker on top of a building and a boy on the ground. In the other situation, there is a loudspeaker on the ground and a boy on the top of a building. When the loudspeaker emits a sound, in which situation would the boy be able to hear the louder and clearer sound?” The settings of Question 4 were that there were two identical loudspeakers and that one speaker emitted a louder sound than the other. The participants were asked to answer which sound was faster than the other. In Question 3, since sound is not gravity-sensitive, the direction of sound propagation is not related to its loudness or clarity. In Question 4, since sound propagation velocity is not related to its loudness, the velocities of both sounds are the same. However, if the participants attributed weight to sound, they would probably say that there are some differences between the two situations both in Questions 3 and 4.

3) Procedure

Questioning was implemented in paper-and-pencil style. Participants were given a set of A4-size papers. Each paper had one question, and they were asked to choose one item from multiple choices and to write the reason for their choice. The order of the papers was randomized. The children were tested as a classroom unit during morning study before the first lesson. As for the university literature and physics students, several at a time were tested in a quiet room. In all three groups, the participants were told that they were going to be asked about sound and that these questions did not relate to their performance at their school, in advance of being questioned. Talking to each other was not permitted until they had completed the questions.

4) Analysis

Participants’ descriptions were mainly used for analysis because multiple-choice questions tend to overestimate participants’ ability (Vosniadou, Skopeliti and Ikosmentaki, 2004). Therefore, their choices were used as a secondary measure only when it was difficult to interpret their descriptions.

Participants’ explanations for Question 1 were classified into the following three categories: (a) attributing substantiality to sound, (b) not attributing substantiality to sound, and (c) no answer or impossible to understand. The point is not whether they considered that the sound of the alarm clock in each box could be heard, but the reason that they thought sound could or couldn’t pass
through a solid structure. When participants thought that in order for sound to pass through a solid structure, it should be thicker or stronger (harder) than the material of the box, or there must be some space for sound to pass through (e.g., invisible tiny holes), their explanations were classified as Category (a). Participants whose explanations were classified as Category (b) answered the question in terms of the sound vibratory process. For Question 2, participants’ explanations were mainly analyzed and classified into the above three categories. The criteria were the same as for Question 1. Participants who did not write any explanation and those who explained “just by guess” or “because I think so” were classified as Category (c), because these explanations were different from those of the other categories.

Participants’ explanations for Question 3 and 4 were classified into the following three categories: (a) attributing weight to sound, (b) not attributing weight to sound, (c) no answer or impossible to understand. As with the analyses of Question 1 and 2, their answers were used only as a secondary measure used to interpret their explanations. In Question 3, when participants referred to the effect of influence or wrote that the sound from the top of building would fall down, they were classified as Category (a), whereas those who explained that the direction in which sound travels was not related to its loudness or clarity were classified as Category (b). In Question 4, when participants considered sound to have some weight and thus there would be some difference between the sounds with higher and lower volume, their explanations were classified as Category (a). Those classified as Category (b) considered that a sound’s propagation velocity was not related to its volume. The criterion for Category (c) was the same as that of the questions for substantiality.

III. Results
1) Properties of material
1.1) Substantiality

Two graduate students on a psychology course classified all participants’ explanations (Cohen’s $k$ was .85 for Question 1 and .89 for Question 2). When their classifications differed, the categories were decided through discussion. The number and percentage of each category for Questions 1 and 2 are shown in Table 1. After excluding Category (c), binomial analyses were applied for each group. In the children’s group, significantly more participants attributed substantiality to sound for both Question 1 and Question 2 (both $p<.01$). Most of them (89%) referred to strength or corpuscular nature in Question 1. Some examples were: “The sound can pass through the paper box because paper is thin and not hard, but wood and iron are very hard, so the sound cannot pass through” and “There are tiny holes in paper and wood but not in iron. So the sound can pass through only when a box is made of paper or wood.” Also in Question 2, most of them (73%) tended to consider that we cannot hear a sound through a wall unless there is a space or hole in it.

Most of the university literature students (88%) also attributed substantiality to sound for Question 1 ($p<.01$), giving explanations quite similar to the children. Although there was no significant difference between Category (a) and Category (b) in Question 2 ($p=.82$), the university literature students classified into Category (a) referred to a space for sound to pass through. That is, they considered

| Table 1. The number of each category for Question 1 and 2 |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Category                        | Question 1       | Question 2       |                  |                  |                  |                  |
|                                 | 5th grader       | Literature student | Physics student | 5th grader       | Literature student | Physics student |
| a Attributing substantiality    | 62 (89)          | 22 (88)          | 7 (25)           | 51 (73)          | 11 (44)          | 14 (50)          |
| b Not attributing substantiality| 2 (3)            | 3 (12)           | 20 (71)          | 2 (3)            | 9 (36)           | 13 (46)          |
| c No response or impossible to interpret | 6 (9) | 0 (0) | 1 (4) | 17 (24) | 5 (20) | 1 (4) |
| Total                           | 70 (100)         | 25 (100)         | 28 (100)         | 70 (100)         | 28 (100)         | 28 (100)         |

N.B. Numbers in parentheses show the proportion of participants in each category rounded to the nearest integer.
that we cannot hear a sound when there is no hole because some space is necessary for sound to travel through.

Contrary to the children and the university literature students, most of the university physics students (71%) did not attribute substantiality to sound in Question 1 ($p<.05$). They explained that the sound of an alarm clock would vibrate the boxes and in turn, the air outside them would be vibrated. Seven participants classified into Category (a) considered that some space was necessary in order to hear the sound of the alarm clock in the box or wrote, for example, “If the sound is stronger than paper, wood, or iron, we can hear it.” In Question 2, there was no significant bias between the number for Categories (a) and (b), but the explanations of those who were classified into Category (a) concerned the thickness of the wall or space for sound to pass through.

1.2) Weight

Two graduate students on a psychology course classified all participants’ explanations (Cohen’s $k$ was .88 for Question 3 and .86 for Question 4). When their classifications differed, the categories were decided through discussion. Table 2 shows the number and percentage of each category for Questions 3 and 4. After excluding Category (c), binomial analyses were applied to each group. According to the results, significantly more children attributed weight to sound both in Questions 3 and 4 (both $p<.01$). Most of them (61% for Question 3 and 79% for Question 4) referred to the influence of gravity on a sound’s volume or clarity and velocity. Some examples in Question 3 were as follows: “Sound falls down by gravitation” or “Sound can go downward more easily than upward.” One example in Question 4 was as follows: “The louder the sound is, the bigger its size is. Thus, a sound with higher volume goes slower than one with a lower volume, the same as an object with a bigger size going slower than one with a smaller size.”

About 70% of the university literature students also attributed weight to sound for Question 3 ($p<.01$), giving almost the same explanations as the children. Although there was no significant difference between Category (a) and Category (b) in Question 4 ($p=.23$), the university literature students classified into Category (a) referred to the relationship between volume and size. That is, they considered that the size of the sound with higher volume was bigger than the one with lower volume.

For the university physics students’ results of Question 3, 22 students (79%) considered that the sound going down would be louder than the one going up because of gravity. In Question 4, however, there were only three participants who attributed weight to sound and explained that the sound with the higher volume had greater weight and it thus went slower than the one with the lower volume. Most of the other participants (89%) explained that the volume of sound did not have any influence on its propagation velocity.

### 2) Consistency of attributing each property to sound

In order to examine whether the participants consistently attributed substantiality or weight to sound even when the task situations altered, the results of two questions for each property were arranged in a cross table (Table 3). Participants who were classified into Category (c) in either question were excluded. According to the re-

<table>
<thead>
<tr>
<th>Category</th>
<th>Question 3</th>
<th>Question 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5th grader</td>
<td>Literature student</td>
</tr>
<tr>
<td>a Attributing weight</td>
<td>43 (61)</td>
<td>18 (72)</td>
</tr>
<tr>
<td>b Not attributing weight</td>
<td>19 (27)</td>
<td>7 (28)</td>
</tr>
<tr>
<td>c No response or impossible to interpret</td>
<td>8 (11)</td>
<td>5 (20)</td>
</tr>
<tr>
<td>Total</td>
<td>70 (100)</td>
<td>25 (100)</td>
</tr>
</tbody>
</table>

N.B. Numbers in parentheses show the proportion of participants in each category rounded to the nearest integer.
Table 3. Cross table of two questions for substantiality and weight

<table>
<thead>
<tr>
<th>Substantiality</th>
<th>Question 1</th>
<th>Question 2</th>
<th>5th grader</th>
<th>Literature student</th>
<th>Physics student</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute</td>
<td></td>
<td></td>
<td>45 (92)</td>
<td>10 (50)</td>
<td>4 (15)</td>
</tr>
<tr>
<td>Not attribute</td>
<td></td>
<td></td>
<td>2 (4)</td>
<td>7 (35)</td>
<td>3 (11)</td>
</tr>
<tr>
<td></td>
<td>Attribute</td>
<td></td>
<td>2 (4)</td>
<td>1 (5)</td>
<td>10 (37)</td>
</tr>
<tr>
<td>Not attribute</td>
<td></td>
<td></td>
<td>0 (0)</td>
<td>2 (10)</td>
<td>10 (37)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>49 (100)</td>
<td>20 (100)</td>
<td>27 (100)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weight</th>
<th>Question 3</th>
<th>Question 4</th>
<th>5th grader</th>
<th>Literature student</th>
<th>Physics student</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute</td>
<td></td>
<td></td>
<td>40 (66)</td>
<td>8 (32)</td>
<td>3 (13)</td>
</tr>
<tr>
<td>Not attribute</td>
<td></td>
<td></td>
<td>2 (3)</td>
<td>10 (40)</td>
<td>19 (83)</td>
</tr>
<tr>
<td>Attribute</td>
<td></td>
<td></td>
<td>9 (15)</td>
<td>1 (4)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Not attribute</td>
<td></td>
<td></td>
<td>10 (16)</td>
<td>6 (24)</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>61 (100)</td>
<td>25 (100)</td>
<td>23 (100)</td>
</tr>
</tbody>
</table>

N.B. Numbers in parentheses show the proportion of participants in each category rounded to the nearest integer.

sults, about 90% of the children consistently attributed substantiality to sound, and there was no child who did not attribute it to sound at all. About 60% consistently attributed weight to sound in both questions, whereas 10 children (16%) did not. Nine (15%) attributed weight to sound in Question 2, but not in Question 3.

Half of the university literature students consistently attributed substantiality to sound, whereas 10% consistently did not. Seven (35%) out of 17 who attributed substantiality to sound in Question 1 did not do so in Question 2. Also, 32% of them consistently attributed weight to sound, while 24% did not. Ten (40%) out of 18 who attributed weight to sound in Question 3 did not do so in Question 4.

Four of the university physics students (15%) consistently attributed substantiality to sound in both Questions 1 and 2, while 10 (37%) did not. Half of those who did not attribute substantiality to sound in Question 1 attributed it in Question 2. For the questions of weight, there was only one participant who did not attribute it to sound in either question. More than 80% of them attributed weight to sound only in Question 3 but not in Question 4.

IV. Discussion

1) Sound as a kind of material

One purpose of the present study was to examine how children before formal learning and university students understand sound. According to the results, most of the children consider sound as a kind of material. Specifically, they attributed substantiality and weight to sound, though these are properties of materials from a scientific view. Four intuitive and scientifically incorrect understandings of sound were identified based on their explanations. Two understandings concern substantiality. The first understanding is that a sound cannot pass through a solid structure unless there is some space. The second is that a sound can pass through a solid structure when it is harder or stronger than the solid structure. The third and fourth understandings concern weight. The third is that a sound going down is louder and be heard more clearly than a sound going up because of gravity. And the fourth one is that a sound with higher volume is bigger and can thus go faster than a sound with lower volume. These types of intuitive understandings were also observed both in university literature and physics students, and no other type was identified. That is, intuitive knowledge of sound possessed by 5th-grade children was
qualitatively equivalent to that of university literature and physics students. These four types of informal understandings were also identified in Mazens and Lautrey (2003). They argued that these scientifically incorrect understandings were gradually revised in everyday life by the age of 10 except the first one. However, the results of the present study showed that some university students did have these four understandings.

2) Comparison between children and university students

Both the 5th-grade children and the university students attributed substantiality and weight to sound and had similar understandings of sound. However, the pattern of their answers in the different task situations varied among groups. The children seemed to consistently attribute substantiality or weight to sound even when the task situations changed. On the other hand, many of the university students attributed them in one situation but not in another situation. These results suggest that university students understand sound in a somewhat correct way compared with children, but do not have a completely scientific view.

Furthermore, the patterns of answers were different between the university literature and the physics students. There were fewer university literature students who consistently attributed substantiality or weight to sound, and there were more who consistently did not compared to the children. In the group of physics students, the same tendency was observed in the questions for substantiality, while there were fewer who did not attribute weight to sound in neither situation compared to the children and the literature students. That is, the property of substantiality is gradually excluded from sound as more scientific conceptions are acquired. But for the property of weight, the effect of the exposure to scientific knowledge is more limited. These results do not support Mazens & Lautrey's (2003) findings that the property of substantiality was more robust and resistant to change than that of weight.

3) Practical Implications and challenges for future research

The results of the present study suggest four types of intuitive knowledge of sound, which continue after formal learning. These understandings are based on the idea that sound is a kind of material. Furthermore, the property of weight seems to be more robust than the property of substantiality, and it may not be completely revised by existing scientific education only. However, it is still unclear why most of the university physics students based their answers on intuitive knowledge in Question 3, but not in the other questions. One possible interpretation is that the situation of question 3 was vague, so that the university physics students, who have a great deal of scientific knowledge, may take other factors into account. This is plausible because there were more physics students who did not give any explanation of their answer in Question 3 than in the others. Although a more well-defined task situation may decrease to some extent the number of participants excluded from analysis, it also carries the risk of manipulating their answers (Vosniadou et al., 2004). Future research should develop tasks with adequate validity and confirm these understandings by employing large samples, using an extended, individual interview. In addition, what impacts these understandings have on formal learning of sound and how to revise them should also be examined.

References


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**APPENDIX**

**Question 1**

ある時間になると音がするようにセットした自覚まし時計を、
紙でできた箱、木でできた箱、鉄でできた箱の中に入れます。

(1) セットした時間になったとき、紙の箱、木の箱、鉄の箱の中に入れられた自覚まし時計の音は聞こえますか。①聞きえる、②聞きえない、どちらかをえらび、えらんだ理由も書いてください。

(2) 紙の箱、木の箱、鉄の箱に入れた自覚まし時計の音の大きさはどうなりますか。

**Question 2**

部屋の中に男の子がいて、隣の部屋にラジカセがあります。

(1) ラジカセから音を出すとき、(ア)(イ)(ウ)のかべで男の子は音を聞くことができますか。①聞きえる、②聞きえない、どちらかをえらび、えらんだ理由も書いてください。

(2) (ア)(イ)(ウ)のかべで、男の子が聞くことのできる音の大きさはどうなりますか。

**Question 3**

(ア)では、ビルの上にスピーカーが取り付けられていて、スピーカーから出る音をビルの下で聞きます。(イ)では、ビルの下にスピーカーが取り付けられていて、スピーカーから出る音をビルの上で聞きます。スピーカーの音の大きさは同じとき、(ア)と(イ)ではどちらの方がよく音が聞きえると思いますか。

**Question 4**

2つのラジカセがあります。(ア)のラジカセからは最大の音量で、(イ)のラジカセからは(ア)の半分の音量で音を出します。この音をある男の子が聞くとき、(ア)と(イ)のどちらのラジカセの音が先に聞きえると思いますか。

(1)〜(3)からえらんで、えらんだ理由も書いてください。

**APPENDIX**

**Question 1**

ある時間になると音がするようにセットした自覚まし時計を、
紙でできた箱、木でできた箱、鉄でできた箱の中に入れます。

(1) セットした時間になったとき、紙の箱、木の箱、鉄の箱の中に入れられた自覚まし時計の音は聞こえますか。①聞きえる、②聞きえない、どちらかをえらび、えらんだ理由も書いてください。

(2) 紙の箱、木の箱、鉄の箱に入れた自覚まし時計の音の大きさはどうなりますか。

**Question 2**

部屋の中に男の子がいて、隣の部屋にラジカセがあります。

(1) ラジカセから音を出すとき、(ア)(イ)(ウ)のかべで男の子は音を聞くことができますか。①聞きえる、②聞きえない、どちらかをえらび、えらんだ理由も書いてください。

(2) (ア)(イ)(ウ)のかべで、男の子が聞くことのできる音の大きさはどうなりますか。

**Question 3**

(ア)では、ビルの上にスピーカーが取り付けられていて、ス
ビーカーから出る音をビルの下で聞きます。(イ)では、ビルの下にスピーカーが取り付けられていて、スピーカーから出る音をビルの上で聞きます。スピーカーの音の大きさが同じとき、
(ア)と(イ)ではどちらの方がよく音が聞きえると思いますか。

(1)〜(3)からえらんで、えらんだ理由も答えてください。

**Question 4**

2つのラジカセがあります。(ア)のラジカセからは最大の音量で、(イ)のラジカセからは(ア)の半分の音量で音を出します。この音をある男の子が聞くとき、(ア)と(イ)のどちらのラジカセの音が先に聞きえると思いますか。

(1)〜(3)からえらんで、えらんだ理由も書いてください。男の子と(ア)、(イ)のラジカセは同じだけはなれていません。