

## Purpose

Physical law such as direction of gravity on the earth plays an important role in solid, liquid, gas matter interactions (ecological events) producing sounds. At the present study, we conducted an experiment of shaking events to demonstrate the relationship between the discrimination accuracy of event-producing sounds and gravitational direction using shaking sound. In our experiment, we examined two shaking directions and amounts of contained pellets.

## Method

**Participants.** 24 undergraduate students who had no hearing problems.

**Stimuli for listening.** The two kinds of pellets were separately contained in the metallic cylinders. The sounds of shaking each cylinder by a hand were recorded. Each trial consisted of five shaking strokes.

### Experimental conditions.

**Vertical-small:** Shaking direction was vertical, and amount of pellet was small.  
**Vertical-large:** Shaking direction was vertical, and amount of pellet was large.

**Horizontal-small:** Shaking direction was horizontal, and amount of pellet was small.  
**Horizontal-large:** Shaking direction was horizontal, and amount of pellet was large.

## Procedure

40 trials were presented to each participant. They were then required to report which of the four kinds of sound stimuli they had heard.

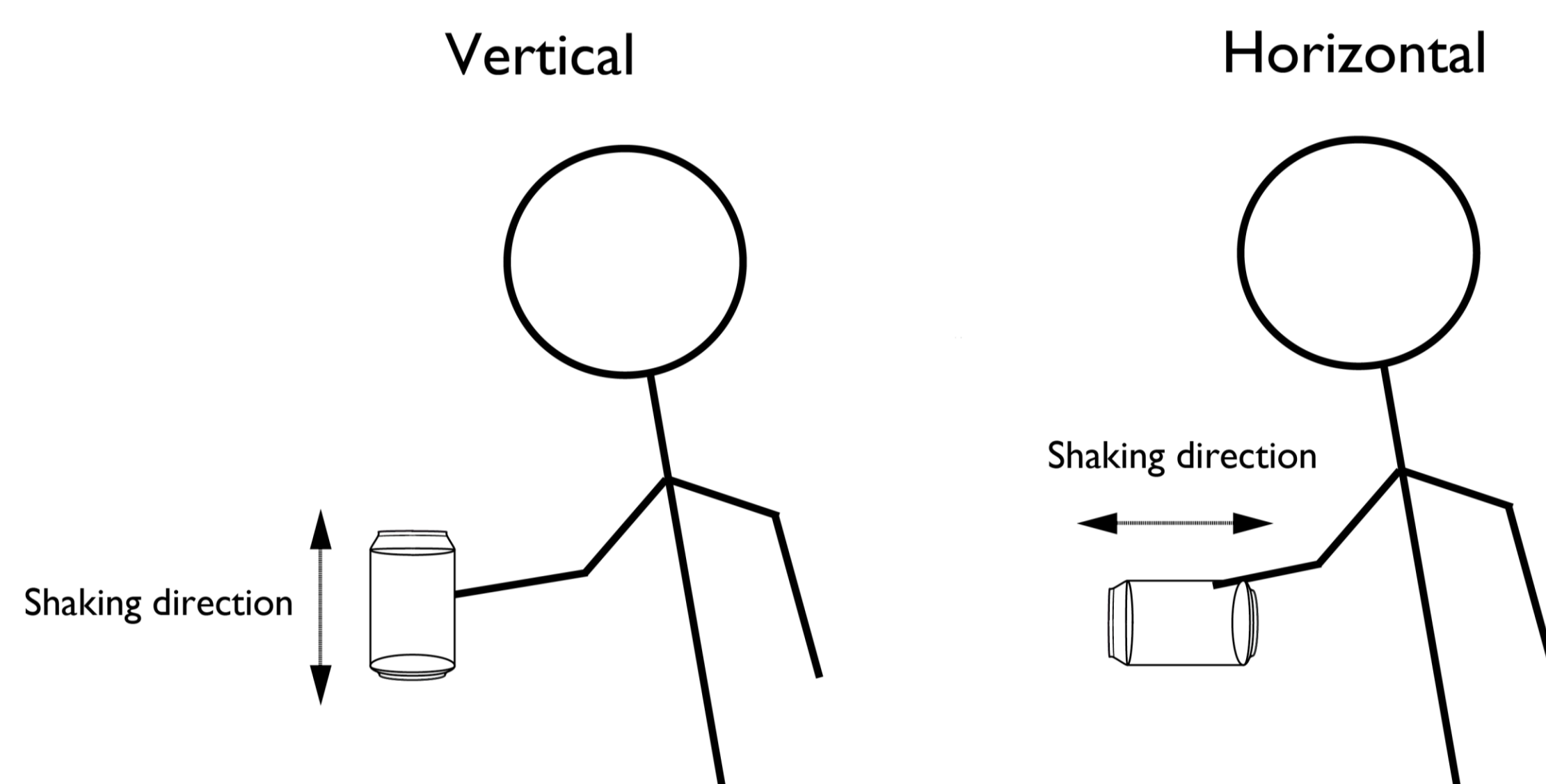


Figure 1. Direction of shaking motion in two impact events. (Diameters and heights equal to 75 mm).

## Results and Discussion

### Judgments of shaking direction and pellet amounts.

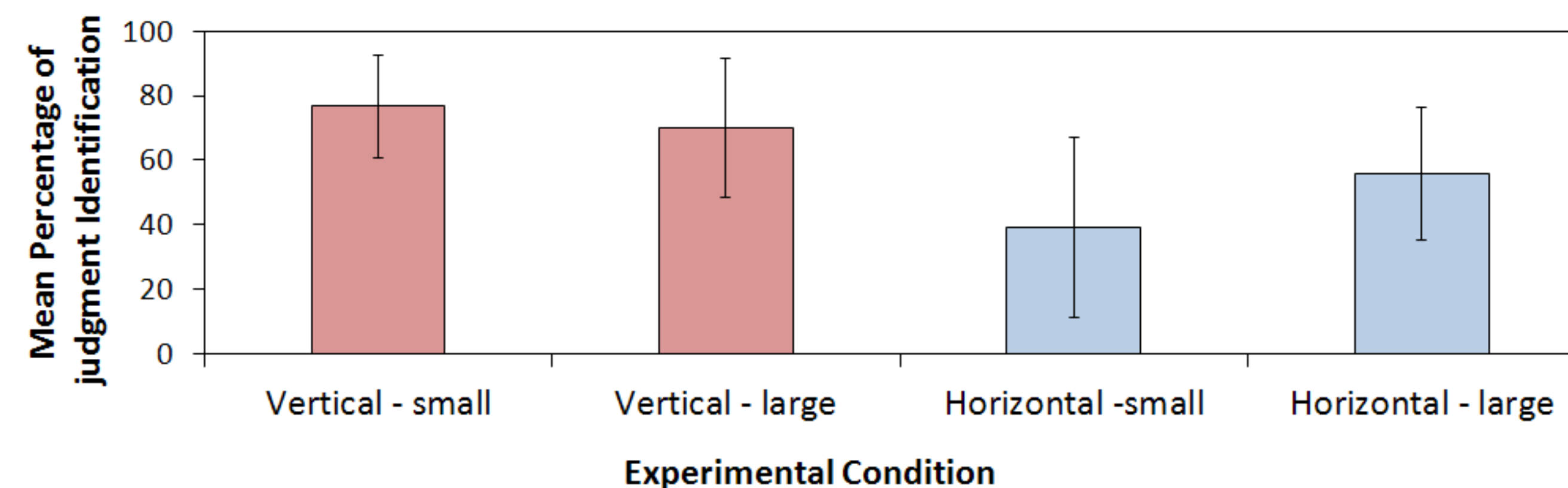


Figure 2. Mean percentages of constancy in the four conditions. Vertical-small 76.67, Vertical-large 70.00, Horizontal-small 39.17, Horizontal-large 55.83.

In general, the vertical shaking sounds were identified more accurately than the horizontal shaking sounds without any feedback.

### The relationship between the judgments and acoustic features of the shaking sounds.

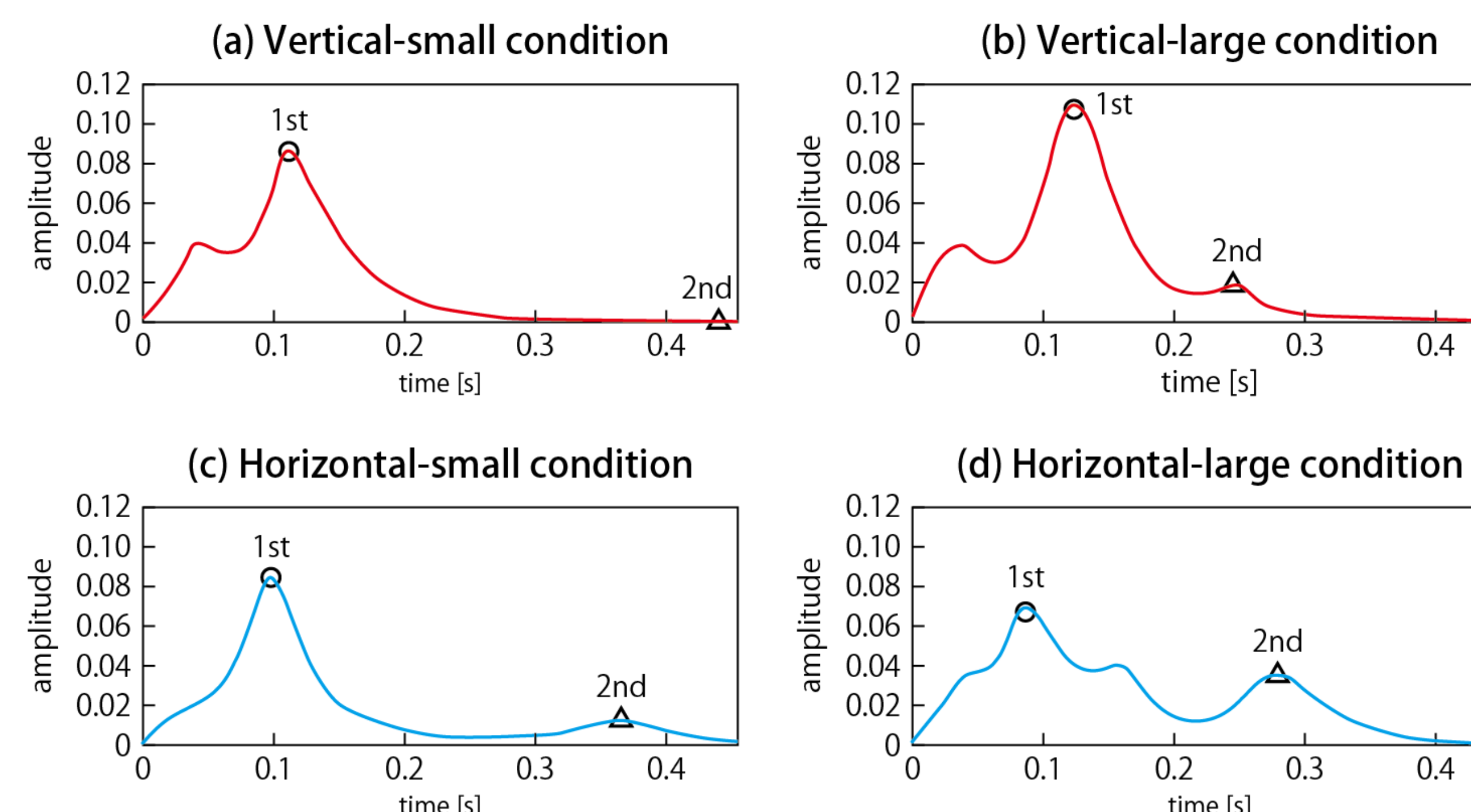


Figure 3. Depictions of the amplitude envelopes of shaking sounds for all four conditions. (a) Vertical-small condition, (b) Vertical-large condition, (c) Horizontal-small condition, (d) Horizontal-large condition.

For acoustic analysis of the different types of shaking events, we calculated the amplitude envelopes of the recorded sounds in each condition.

There were two types of amplitude envelope for the different directions of shaking.

The vertical shaking sounds having only one peak component. The horizontal shaking sounds having two peak components. The first peak appeared high, consequently, the second component appeared relatively low.

## Discussion

The contact of the pellets with the inside of the container produced various stroke (burst) sounds that depended on the shaking direction or pellet amount. Such different events can be characterized by different amplitude envelopes that include one or more peak components. Hence, the properties of the amplitude envelopes of the events were considered cues for specifying the shaking events.

The direction of shaking the container and the pellets amount produce different impact events.

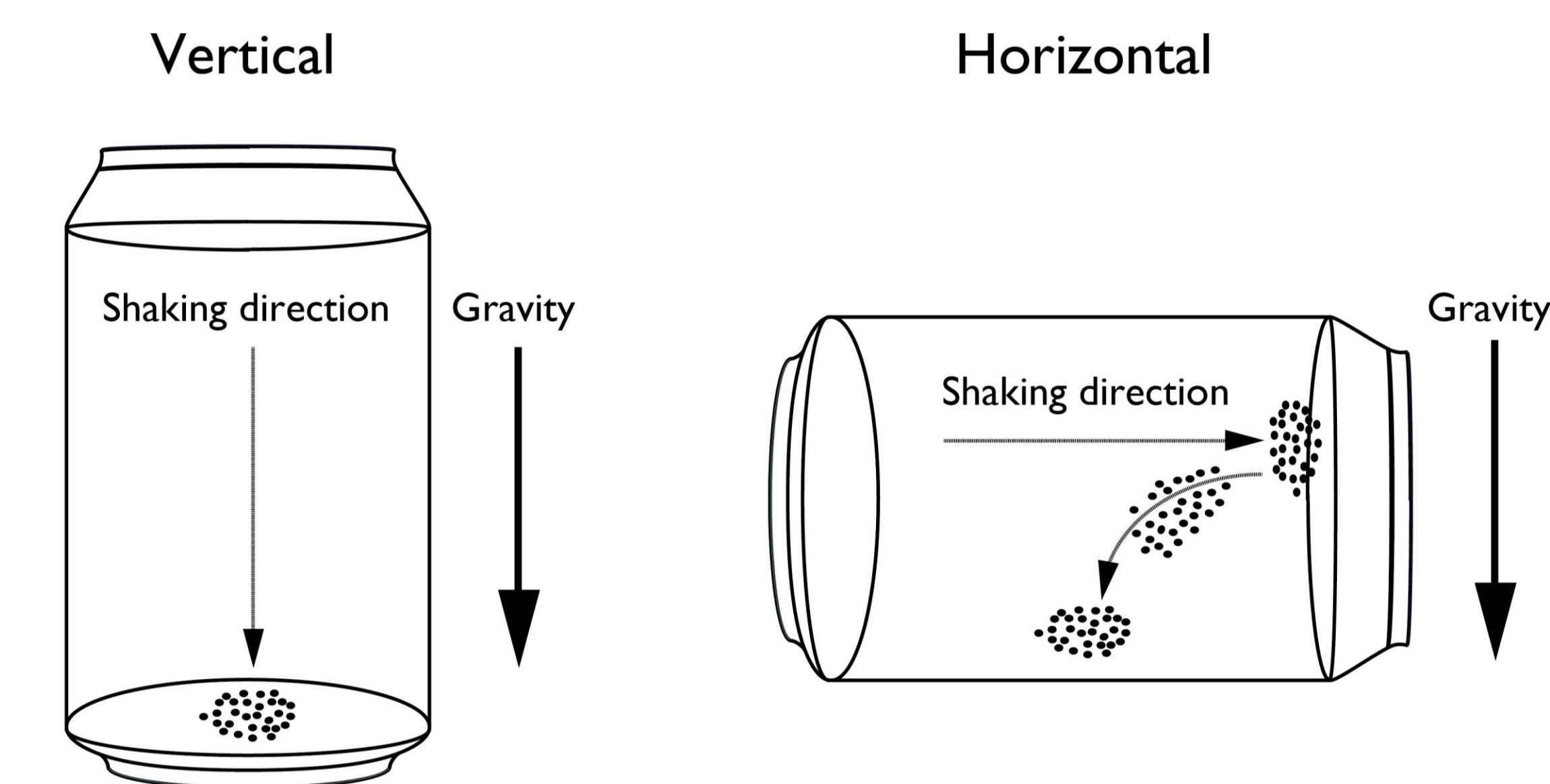


Figure 4. Relationship between direction of shaking motion and gravitational direction in two impact events.

When the container is shaken vertically, the direction of shaking motion is corresponded to the gravitational axis.

In this case, the pellets strike the bottom of the container and such state keeps for a moment.

When the container is shaken horizontally, the direction of shaking motion is orthogonal to gravitational axis.

In such case, the pellets strike the side wall and immediately fall to the bottom of the container due to gravity, thereby yielding two impact events.

## References

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