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Abstract

Virtual data collections have become increasingly popular in recent years because of their benefits to research. The goal of the study was to create a virtual data collection method to examine how parents teach their children to think spatially. Specifically, the long-term goal was to create a virtual method to observe how natural parental interactions can influence a child's performance on a spatial task. To create the virtual method, we first explored how other researchers use virtual methods. Using already published methods as a starting point, through trial and error, we focused on creating a virtual method that is inclusive for all participants, easy and convenient for parents, and able to capture the essence of an interactive in-person study. The results of the study will be used to conduct virtual data collection in the coming years to enrich the understanding of parents' influence on their children's development while expanding the tools available for studying early development.

1. Creating a Virtual Method to Examine Parents' Impact on Spatial Problem-Solving

Research is impossible without data, which are collected systematically from participants through experimental tasks, observations, interviews, and surveys (American Psychological Association, 2022). In recent years, there has been a significant shift in how data collection is conducted. Taking advantage of improvements in technology, many researchers have begun incorporating virtual methods to reach a wider pool of participants and collect different types of data. The goal of the current study was to create a virtual data collection method to examine how parents teach their children about a challenging spatial problem. The virtual spatial reasoning task was adapted from an in-person task used in previous studies (Joh & Spivey, 2012). Starting from a previously tested in-person method allowed us to learn more about young children's spatial development while assessing the feasibility and usefulness of a virtual counterpart. Additionally, the virtual data collection method was created to be as inclusive as possible for all participants, easy and convenient for parents, and interactive for children. In the future, the virtual method will be used to examine how parents and children solve spatial problems together.

1.1. Virtual Method of Data Collection

Virtual data collections have become increasingly popular in developmental research. Due to improvements in software and hardware, numerous user-friendly virtual methods are now available with little requirement for complex programming or complicated and costly equipment. For example, researchers post surveys through Qualtrics or Survey Monkey, communicate with participants through WhatsApp or Viber, conduct

interactive interviews through Zoom or Cisco WebEx, create and present animated tasks through Keynote or Microsoft PowerPoint, and share on-screen objects and videos through Adobe Connect or Microsoft Teams (Cuevas-Parra, 2020; Rhodes et al., 2020; Shepperd et al., 2020). Prior to the COVID-19 pandemic, it was typical for live events or video clips to be shown to children during in-person studies. Now, researchers can share their screens, show events to participants, and conduct research virtually (Addyman et al., 2018).

Virtual data collections are also popular because they can be moderated or unmoderated. Moderated research requires the facilitator to be present in-person and allows for live back and forth discussions, as the moderator prompts the participant to discuss their thoughts further (Hertzum et al., 2015). Live interactions are helpful when working with children because they allow researchers to maximize engagement, getting the most out of the data collection session (Sheskin et al., 2020). Contrary to moderated research, unmoderated research does not require the facilitator to be present because the participants complete their tasks independently (Hertzum et al., 2015). Unmoderated research is easily replicable and permits more families from diverse backgrounds to participate (Rhodes et al., 2020). Additionally, unmoderated research allows for the rapid data collection of large samples using platforms already established to collect data with children online. For example, researchers may choose from Discoveries Online, Lookit, and The Music Lab to conduct their research (Sheskin et al., 2020).

Although the COVID-19 pandemic has hastened the development and use of virtual research methods, prior to the pandemic, researchers had begun relying on virtual methods to supplement or replace in-person data collections. There are several important benefits to virtual methods. First, virtual data collections—and virtual recruitment—allow researchers to reach a wider, more diverse pool of potential participants (Rhodes et al., 2020). Researchers are no longer limited to drawing from a geographically close pool of potential participants and participants are no longer limited to volunteering for nearby studies. Instead, if participants have access to the internet, they can take part in research. Researchers have documented the over-reliance on WEIRD (Western, educated, industrialized, rich and democratic) populations in psychology research (Foubert et al., 2021). Virtual data collections, then, may help researchers alleviate the uneven focus on WEIRD populations.

Second, participants may be more likely to volunteer for virtual studies if they are more convenient (Sheskin et al., 2020). Virtual studies remove the commute factor, take up less time out of hectic family schedules, and lessen the hassle of transporting children to and from an unfamiliar environment, such as a university campus. Parents do not have to secure childcare for other children or attempt to bring multiple children to in-person studies. Children may also be more comfortable completing studies from their own home, at a time that is convenient for them.

Third, virtual research methods are good for science. They encourage greater collaboration between researchers because the stimuli, study designs, and data can be shared easily between labs (Sheskin et al., 2020). For example, the online Collaboration for Reproducible and Distributed Large-Scale Experiments (CRADLE) (Sheskin et al., 2020) and ManyBabies (https://manybabies.github.io/) take advantage of different virtual methods and allow labs to replicate the methods and findings from previous studies. Some virtual studies are replicated from previous research conducted virtually, but also from once in-person studies. The latter transitions in-person tasks and research questions into appropriate virtual experiments. Replication is crucial because it provides further support or opposition for previous research findings. This helps to advance scientific research and better understand the field of psychology. Data-sharing archives help

assist the process of replication practices as they are growing in size and becoming easier to navigate (Duncan et al., 2014). While developments in software and hardware have led to virtual research methods that are used today, virtual research methods can also initiate further developments in return. For example, the CRADLE research team invites researchers to provide feedback on their online infrastructure, with the intention of encouraging collaboration and large-scale research.

While there are clear advantages to virtual research methods, there are also several possible impediments to a successful implementation of virtual methods. First, in virtual research, participants must be prepared to take on some of the methodological and technical requirements for the study; participants who are unable to do so may be left out. For example, virtual research requires a stable internet connection, which may not be available to all participants (Shepperd et al., 2020). Studies may also require a safe and quiet space during the session, but such spaces may not be available to everyone (Roberts et al., 2021). Even if participants have access to the necessary equipment and space, unforeseen technical difficulties may arise during the study. While effort can be made to limit such issues as much as possible, the requirement of completing a task virtually may prevent some people from participating.

Second, in virtual research, researchers must be mindful of their additional layer of responsibility involved in meeting with participants from a distance and collecting data remotely. They must build in opportunities to present information clearly during the research process. For example, during the informed consent process, researchers may provide written forms virtually while simultaneously explaining the information to the participants (Rhodes et al., 2020). Researchers may plan to email consent forms prior to the study, allowing participants ample time to read the detailed information and compose questions. When greeting participants during the study, being in a different physical location means researchers must be more engaging to help participants feel comfortable. Or, perhaps researchers need to be more direct and straightforward with instructions, such as when identifying the role of the parent during a study with children, so that data collections can be carried out without interruption from other people who may be present. During in-person data collections, any of the above instances may be addressed easily and on the fly. However, during virtual data collections, the physical distance limits the researcher's ability to engage with participants, requiring researchers to anticipate for various scenarios before starting a study. The researcher needs to also plan ahead to answer any questions that the participant may have (Sheskin et al., 2020). If a participant is completing a virtual study and is confused, they may not feel inclined to go the extra step and email the researcher directly with their question. Consequently, they would either not complete the study or complete it incorrectly. Additionally, the researcher must prepare all study materials in advance to ensure that they are ready in time for the participants. In some cases, this can mean emailing materials to participants in advance. However, for some other studies, such preparation requires mailing the materials. In this case, researchers and participants must plan accordingly for there to be enough time between receiving the materials and conducting the study. Another consideration is how to have participants interact with the researcher and the experiment. In-person research allows for physical behavior, such as touching and moving test stimuli to select a decision or express a choice. However, physical behaviors are not possible in a virtual method. Researchers must put in more effort and make more strategized decisions about how participants can respond and interact with the task virtually.

While keeping the above considerations in mind and acknowledging the benefits of virtual data collection, virtual data collection can be successfully conducted. The COVID-19 pandemic

was a driving factor in the increase of virtual data collection. However, the popularity of this research method began expanding before the pandemic and will likely outlast the pandemic due to its evidence-based advantages.

1.2. Parents' Influence on Children's Spatial Reasoning

An area of interest that researchers can explore through virtual data collection is children's spatial reasoning. More specifically, there is the question of how parents can influence their children's understanding of a spatial task. Spatial reasoning refers to how we think, and problem solve about how objects move, and events occur in space. Spatial reasoning is a critical aspect of broader spatial skills that are important for everyday tasks, as well as achievement and career outcomes in STEM (science, technology, engineering, and mathematics) disciplines (Pritulsky et al., 2020). For young children, this important skill develops over the first few years of life. For example, it is not until about 4 years of age that children can decipher the correct trajectory of an object moving through one of several possible paths (Hood, 1995). Until then, children make incorrect assumptions based on gravity. For example, they might assume that an object dropped down one of several intertwining tubes will fall straight down, even when it is impossible for the object to move in such a way. This phenomenon is known as the gravity bias error.

Indeed, there are reasons to think that parents are important sources of information for young children as they acquire crucial spatial skills. First, parents play a significantly positive role as a teacher by communicating with their children using words that promote spatial reasoning. They use spatially-oriented words which predict spatial skills (Pruden et al., 2011). When parents use those words, it helps children's memory for spatial events (Feist & Gentner, 2007). Parents use spatial language also while spending time working on spatially oriented activities, like toy building blocks (Ferrara et al., 2011). Second, parents create everyday opportunities for learning more broadly. Parental inquiry, such as guided instruction, can help children develop their math abilities and conceptual understanding of scientific topics (Vandermaas-Peeler et al., 2018). Through conversation and experiences, parents also positively influence children's memory. Children are better able to recall events or objects if they discussed them with their mother compared to children who do not talk about them with their mother (Eberbach & Crowley, 2017). Third, parents are motivated to help their children thrive, which in turn influences how the children learn. Parents facilitate how they help their child learn in a method appropriate to their individuality (Leung et al., 2021). Thus, parents are able to better teach their children because of how well they know them.

1.3. Current Study

This study had two goals. The primary, immediate goal was to create a virtual data collection method to examine how parents teach their children to think spatially. The second, long-term goal was to use the virtual data collection method in the future to investigate how 3-year-old children perform on a difficult spatial problem (spatial task) after practicing with a related problem with their parents (learning task). Together, these goals highlight the need for virtual data collection and the benefits of parental teaching to learn more about spatial reasoning in 3-year-old children. To create the virtual data collection method, we focused on three additional requirements: (1) making the method inclusive for as many participants as possible, (2) making it easy and convenient for parents, and (3) making it interactive for children. The method and results are presented together because the process of creating the task was both the method and results of this study.

2. Method and Results

2.1. Requirement 1: Making Research Inclusive for All Participants

Fully virtual method. To include as many participants as possible, a fully virtual method was created. The first part of the study, the Qualtrics survey, was created to be straightforward and short. The Qualtrics survey included a screening to determine participants' eligibility, informed consent forms, a demographic questionnaire, and virtual session scheduling. Becoming familiar with the abilities of the Qualtrics software allowed the survey to be easy to use, engaging, and aesthetically pleasing for the participants.

Recruitment in diverse sites. To allow for an inclusive study, participants will be recruited through listservs, science websites, and word of mouth using approved advertisements. Interested parents will complete the screening survey to determine whether their child is eligible for the study. These recruitment methods were selected after extensive research into how other researchers recruit participants. For example, ManyBabies successfully recruits a diverse pool of participants from Listservs.

2.2. Requirement 2: Creating a Study that is Easy and Convenient for Parents

Qualtrics survey. The survey was created with the purpose of being user-friendly for the participants. A specific intention was to prevent parents from losing interest mid-study or becoming confused, because then they may not finish the survey. If a participant did not finish the survey, then they would not sign up for the virtual video session, and their data would be unusable. Also, the Qualtrics survey's specific response options will allow it to be user friendly. For example, when asking participants which state they live in, an open text box would allow responses such as "New Jersey", "new jersey", or "NJ". Instead, as seen in Figure 1, a drop-down feature will allow parents to answer easily, without confusion on their end, and improve the coding process on the researcher's end.

Creating learning task. Microsoft PowerPoint was used to create worksheets for a learning task that requires similar spatial problem-solving skills as the spatial task (i.e., selecting and following a path to reach a goal). The learning task requires the use of paths going from left to right, whereas the spatial task requires paths going from top to bottom. The worksheets contain line-drawing styled images of items, and paths drawn in a similar width to the line drawings. There are 5 worksheets, with each one getting progressively more difficult, creating an opportunity for interactions between the parent and the child (see Appendix A).

Sharing learning task. Creating a virtual task required anticipating possible issues, such as technological difficulties, and preparing appropriate solutions, such as clear instructions to share with parents. Providing families with the necessary supplies is typically straightforward with in-person data collections because researchers can simply do so at the time of the study. However, a virtual study requires different ways of delivering the parent-child interaction worksheets. As seen in Figure 2, during the Qualtrics survey, parents can indicate whether they would like to receive the worksheets via mail or print them at home. Follow-up questions will allow researchers to ensure that the participants will properly receive the worksheets (i.e., email address, home address, printer access). Both distribution options will be done in advance with enough time prior to their virtual sessions.

2.3. Requirement 3: Designing a Task that is Interactive for Children

Administering learning task. Parents will be asked to work through the five worksheets with their children in any manner that is comfortable for them. The researcher will not play an active role during this task to allow parents and children

to interact as naturally as possible. This approach will allow for the most efficient way in examining how the virtual task facilitated the parents' role as a teacher. Consequently, the task will be interactive for the children because they are not working independently, but rather right alongside their parent.

Administering spatial task. It was critical to decide whether to use a moderated or unmoderated spatial task to make it interactive for children. As described earlier, a moderated approach requires the researcher to be present to guide the participant through the task. Meanwhile, an unmoderated approach does not require the presence of the researcher because the participant completes the task independently. Ultimately, a moderated approach was the most appropriate for the long-term goals of this study. For example, a moderated task allows for back and forth conversations, maximizing the child's participation by demonstrating the task to them live on a Microsoft Teams video call. Choosing Microsoft Teams as the platform for the video sessions was another way to address the goal of interactivity. Microsoft Teams is supported by Seton Hall and Seton Hall students are familiar with the program, making it convenient for trouble shooting, recording sessions, and scheduling meetings.

To increase interactions during the study, the child will view the spatial task apparatus on the video call. As seen in Figure 3, the participant's view will be of the researcher as they interact with the study's apparatus, guiding the child's participation. For the spatial task, children will see five framed colors, in addition to the chimney apparatus. Using clear plastic frames and colored construction paper, the colors chosen were red, yellow, green, blue, and purple. To prevent any bias, the child will be initially shown the five different colors, and will then select their least favorite and favorite colors. Their least favorite color will not be used again for any aspect of the study. Their favorite color will then be used as the color of the ball during the trials. The remaining three colors will be the colors used at the bottom of the apparatus to help the children identify their choice. The researcher will begin by holding a ball over the top of a tube opening, and asking the child where they must place the cup to catch the ball, at the bottom, underneath one of the three openings.

When this task was previously done in person, the child was able to place a plastic cup at the bottom of the tube to indicate where they thought the ball would come out. However, with virtual data collection, that no longer works. It becomes necessary for the child to identify their choice of where the researcher should place the plastic cup. Several possible ways for children to identify their choice were carefully considered. For example, images, such as types of animals, or items like cars, placed at the bottom opening of the tubes were contemplated. It was also considered to create a way for children to virtually select their choice, or to even use hand signals to identify left, middle, or right as their choice. However, due to potential difficulties or biases, these ideas were not selected. As a solution, colors were chosen as the identifying feature because they are a common part of young children's lives. The children will already be familiar with seeing the different colors, as well as hearing and saying the names of the colors. Aside from the child's favorite and least favorite colors, the remaining three colors were thought to be the most neutral for the child. The rationale here is that this will hopefully prevent the child from picking their favorite color every time or always ignoring their least favorite color. The intention was also to keep the child engaged because their favorite color will be the color of the moving ball through each trial of the spatial task. There was also consideration for how the way the question was asked could potentially affect how the child would think about the task, and make their choice. It was ensured that the wording and method of choice selection would not alter the way the children thought about the spatial task.

3. Discussion

Virtual data collections are more popular than ever and allow researchers to collaborate with other researchers in the field, but require attention to detail and careful planning. The current virtual data collection method was created to be inclusive for all participants, easy and convenient for parents, and interactive for children. If the first goal of making the data collection method as inclusive as possible was achieved, that would open up the sample to reach a more diverse group of people. This could help researchers address the issue with WEIRD participants. By including participants outside of the WEIRD population, the results could be more generalizable, and not reliant on factors such as geographics or education status.

Even though the study was created to be inclusive for all participants, there are limitations. For example, there is an assumption that everyone has a device and internet access to complete the survey and virtual video session. However, this is not always the case. Consequently, individuals without a device or internet access, for example, would be unable to participate in the study even if they matched everything else to be eligible.

Second, through communication and preparation, the virtual method was created to be easy and convenient for parents. However, it is important to acknowledge that in addition to the researchers' responsibilities, there are greater expectations for the participants to correctly complete the study when it is virtual, versus in-person. It is necessary that the participants also put in effort on their end, even if the study is created to be as easy as possible. This is much less of an issue when conducting research in-person because all the participants usually must do is show up. It is also much easier to provide participants with materials in this setting because the researcher can physically provide them with the supplies right there. However, it is important for researchers to put in more effort prior to the virtual study so that the participants have everything they may need at the time of the data collection session.

Third, if the virtual data collection method was created to still capture the essence of the in-person study, then hopefully the findings would replicate the spatial task studies previously done in-person. If participants show better performance on the spatial task after completing the learning task, then the results will suggest that the learning task was an effective method for parents to teach their children how to think spatially. This would mean that the virtual study assesses spatial reasoning in children similarly to the in-person studies . Regarding the parental learning portion, this would mean that parents can positively facilitate their children's spatial reasoning in a way that transfers to a different spatial task. This finding would be extremely interesting, and would support the importance of parents as teachers during their children's development.

In creating the virtual data collection method, we hoped to not only add to the foundation of early virtual methods, but also to create the beginning of collecting data virtually in our own lab. Through the inspiration of other researchers in the field and their generous sharing of their work publicly, we created a virtual method that is inclusive for all participants, easy and convenient for parents, and able to capture the essence of an interactive in-person study. In future studies, we think that the current virtual data collection method should be piloted with a sample of participants, and refined as needed.

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4. Appendix

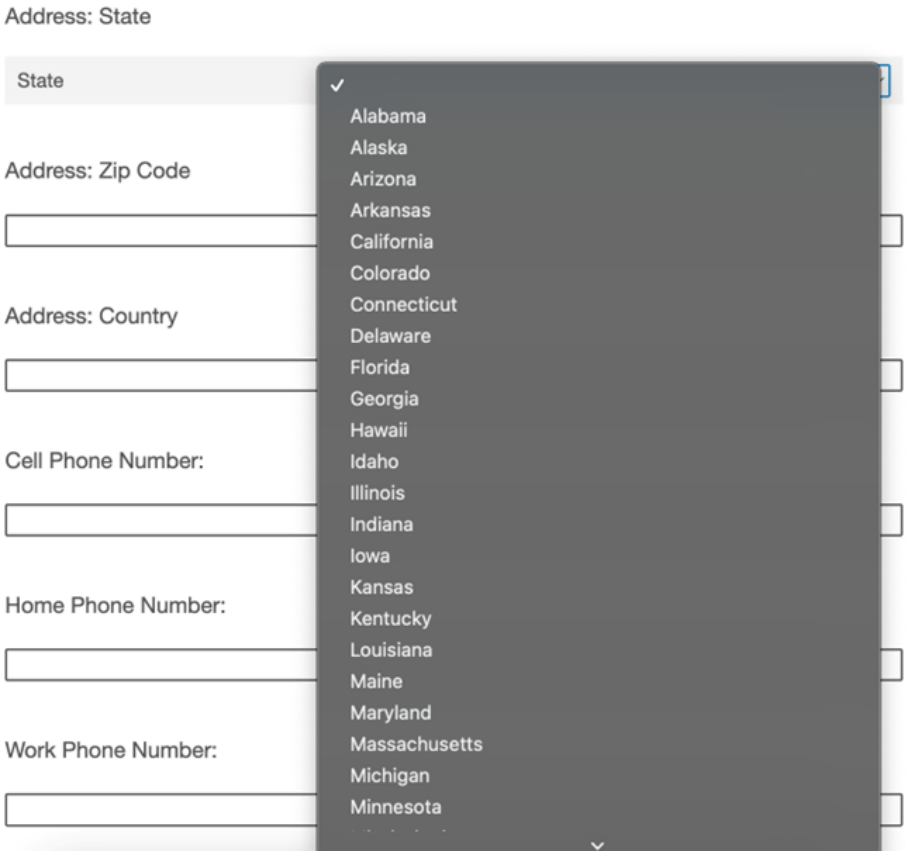

Figure 1. Example of Qualtrics question using a drop-down feature for indicating state of residency

Figure 2. Example of Qualtrics question used to assess whether parent task should be emailed or mailed

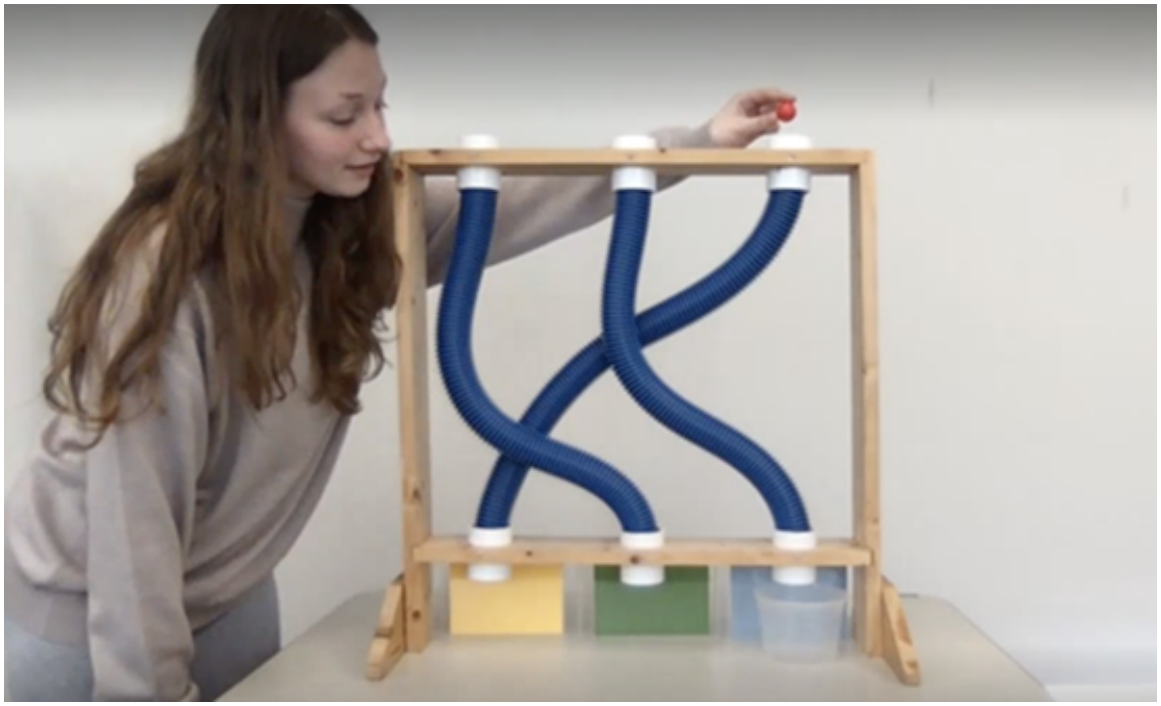

Figure 3. Participant view of researcher during virtual data collection session

4.1. Appendix A
Learning Task Worksheets

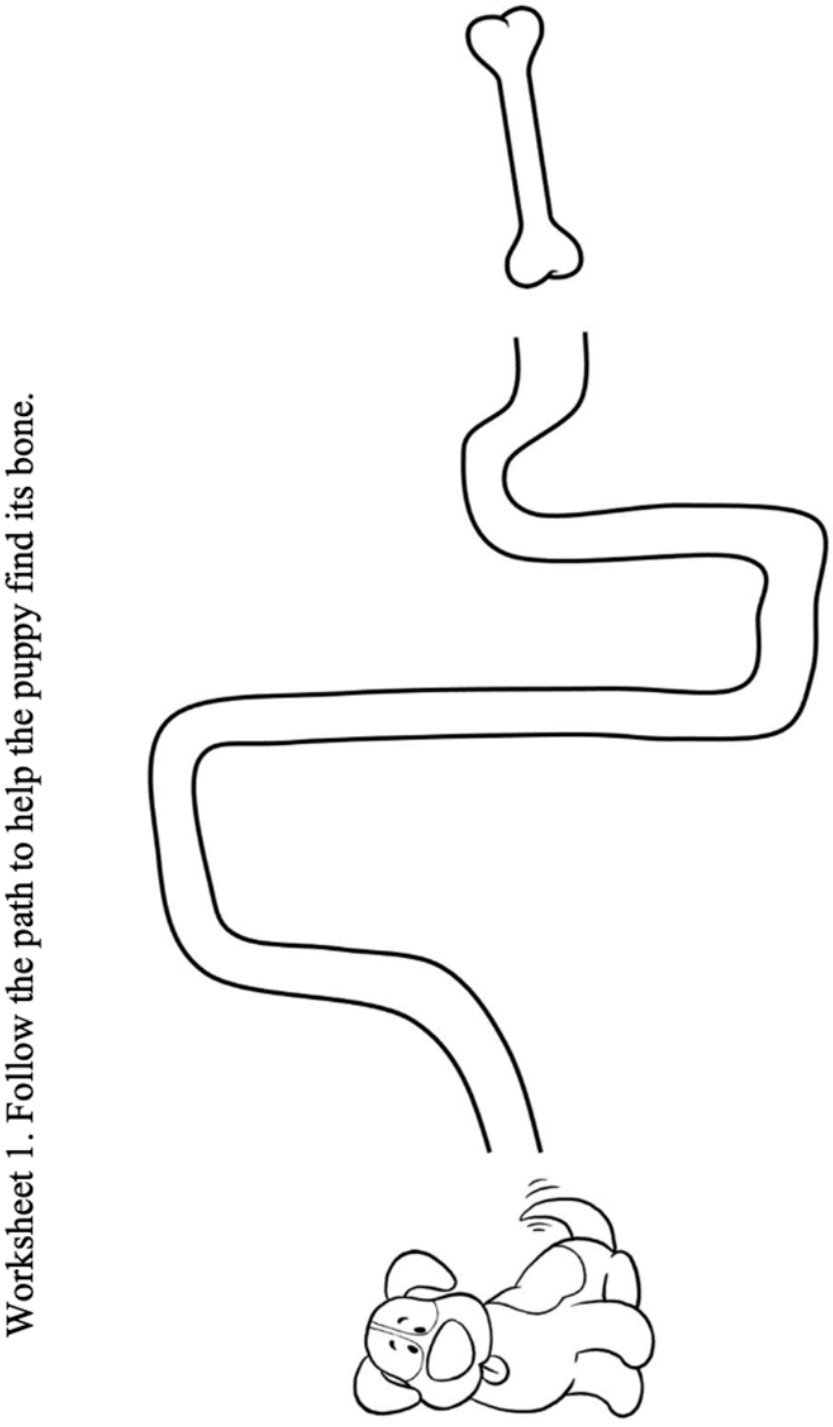

Figure 4. Worksheet 1

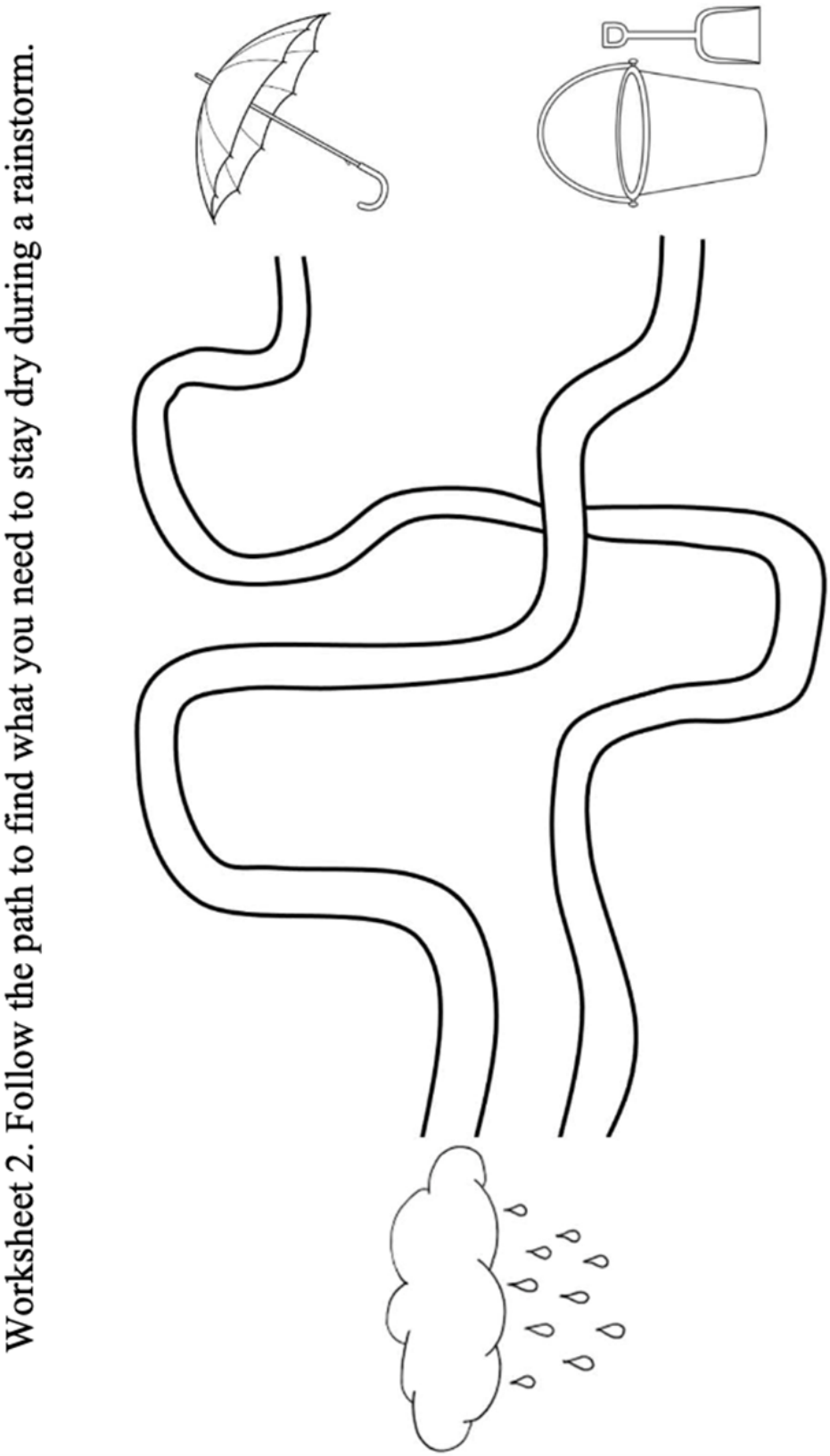

Figure 5. Worksheet 2

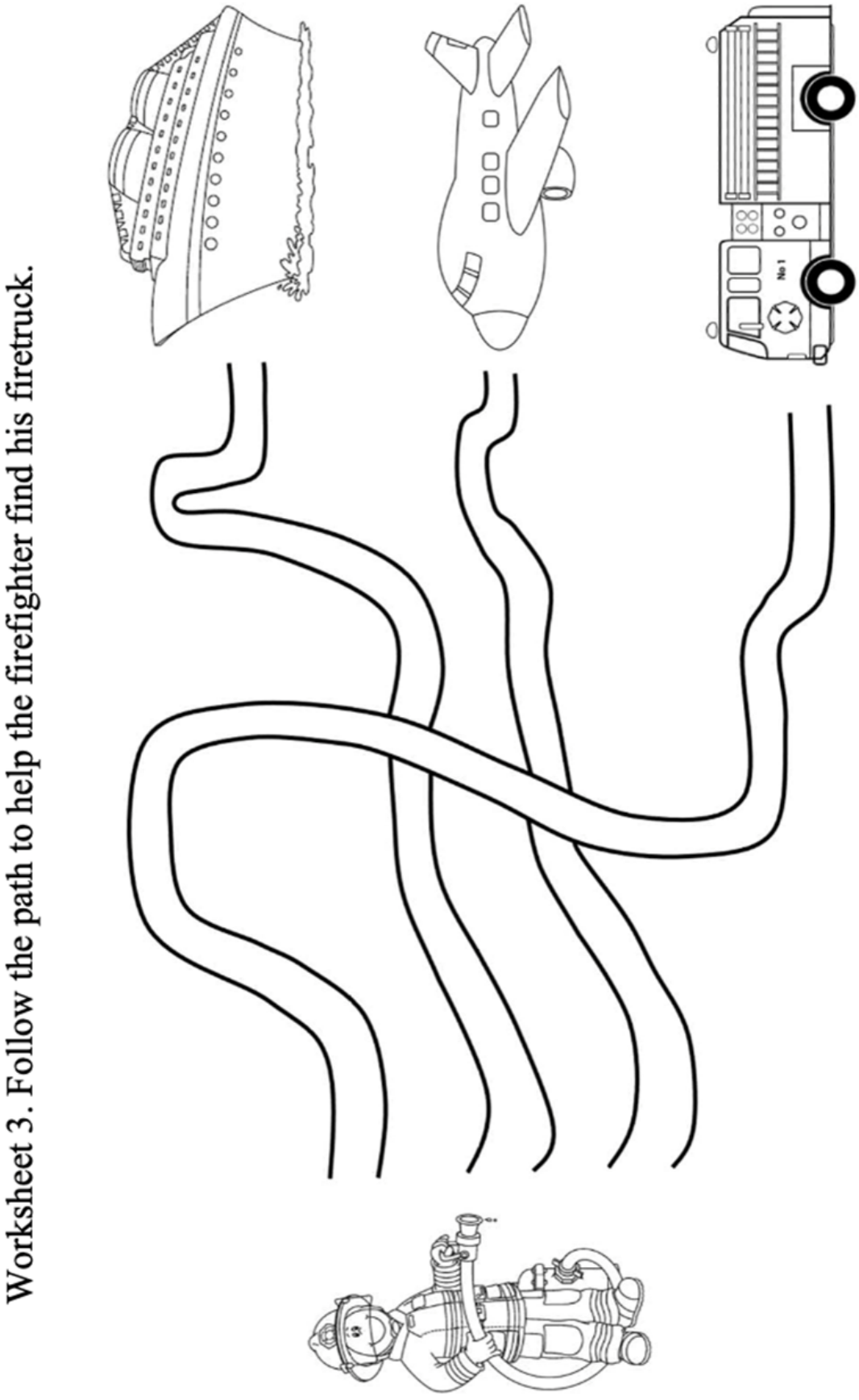

Figure 6. Worksheet 3

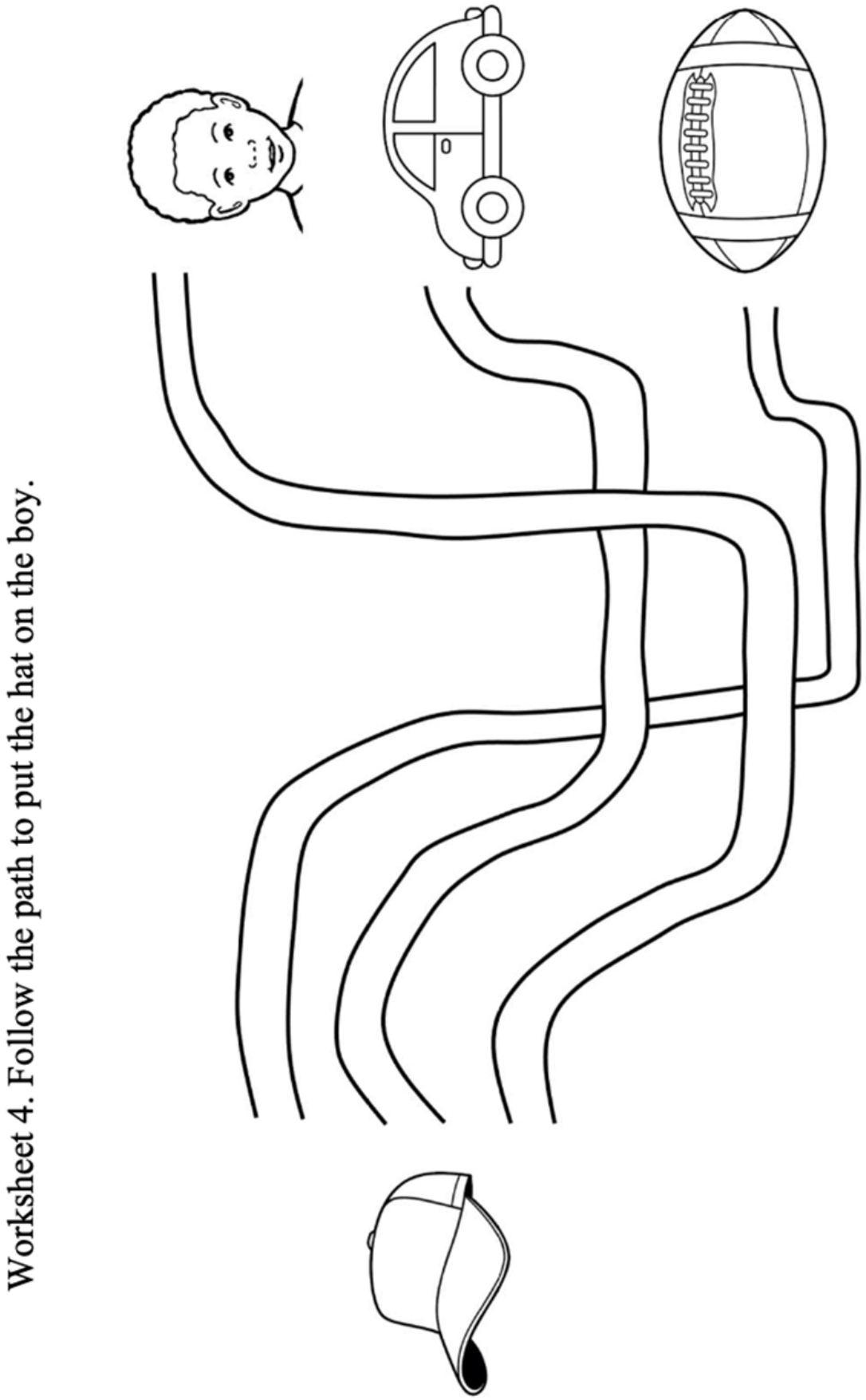

Figure 7. Worksheet 4

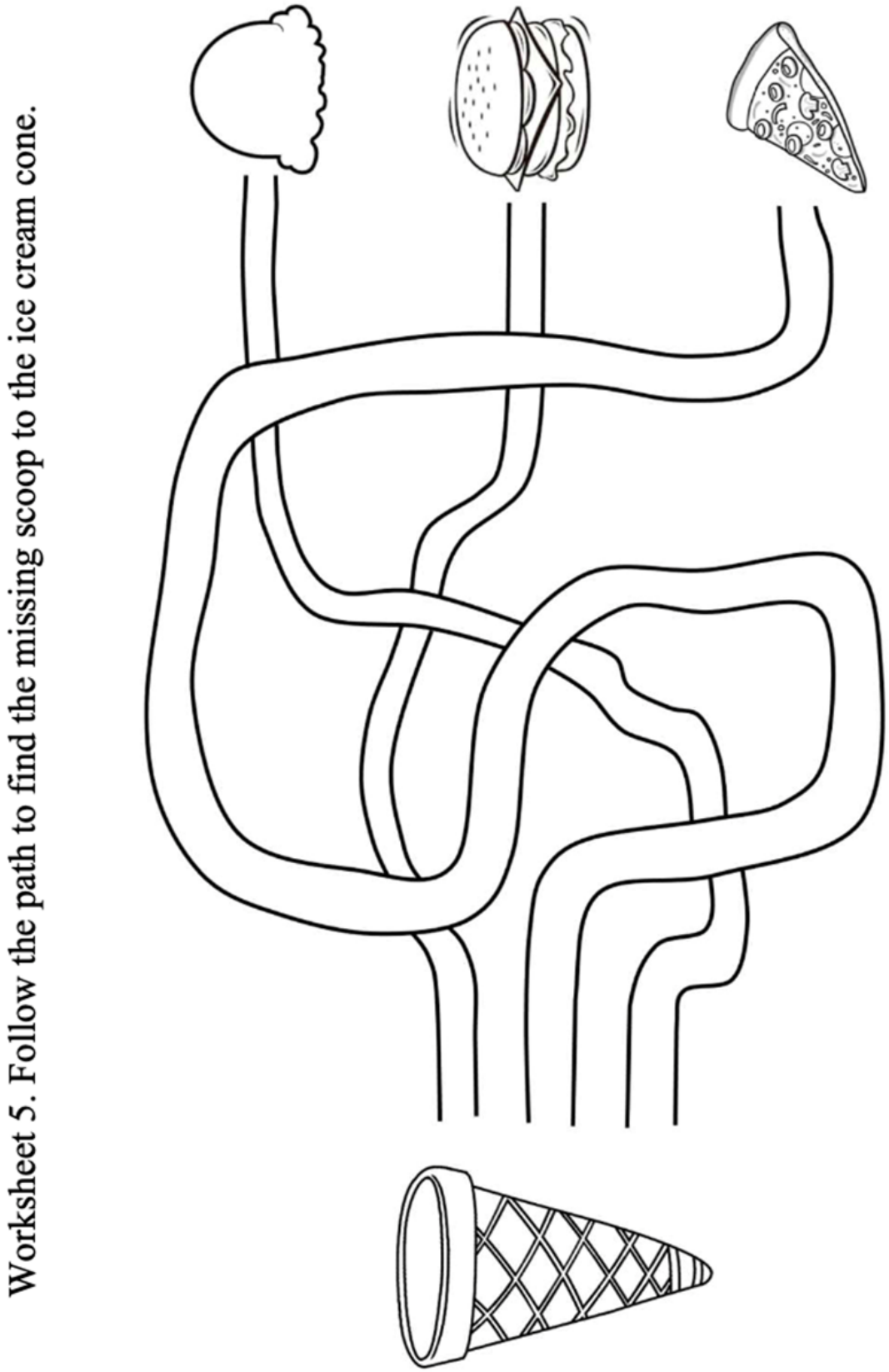

Figure 8. Worksheet 5