

Supplemental Material - MITA Activities

The supplemental materials describe the nine different developmental activities available in the Mental Imagery Therapy for Autism (MITA) application version 3.2, released in 2016.

1. Outlines activity --- Developmental goal: attend to shape, Beginner Game

In our *Outlines* game, a child is asked to match objects with their corresponding silhouettes. This game is modeled after the classic Montessori wooden puzzles and is ideal for teaching a child to notice subtle differences in the shapes of objects, Fig. S1A-C. The *Outlines* game also includes jigsaw puzzles in which a child must assemble larger shapes from a variety of smaller pieces, Fig. S1D-F.

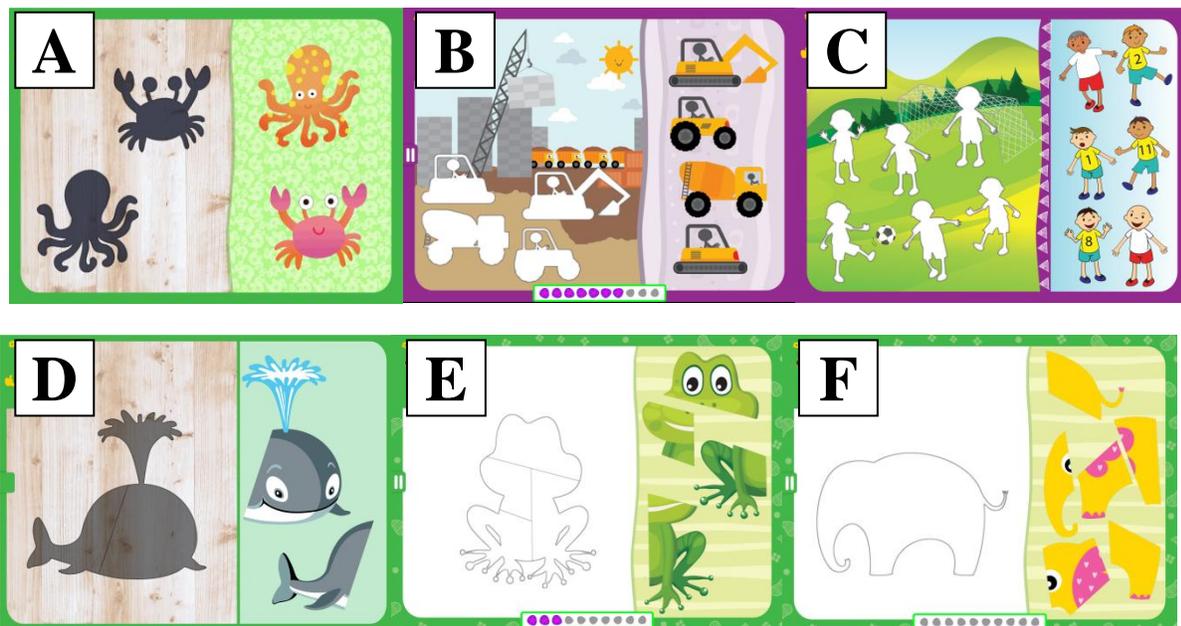


Figure S1. Outlines activity. The objects located on the right of the screen have to be dragged to their respective silhouettes on the left.

- (A) Easy level (2 shapes): Level 1 (of 29).
- (B) Intermediate level (4 shapes): Level 15 (of 29).
- (C) Advanced level (6 shapes): Level 23 (of 29).
- (D) Easy (2 pieces): Level 3 (of 29);
- (E) Intermediate (4 pieces): Level 13 (of 29);
- (F) Advanced: Level 25 (of 29)

2. Patches activity --- Developmental goal: attend to color/pattern, Beginner Game

In the *Patches* game, a child must notice colors and patterns to match cutout pieces to their correct location within a larger image. Together with the *Outlines* game, these two beginner-level games lay the foundation for more advanced games in which a child must notice not only the shape and color of an object, but also other features such as size, orientation and number, Fig. S2A-C.

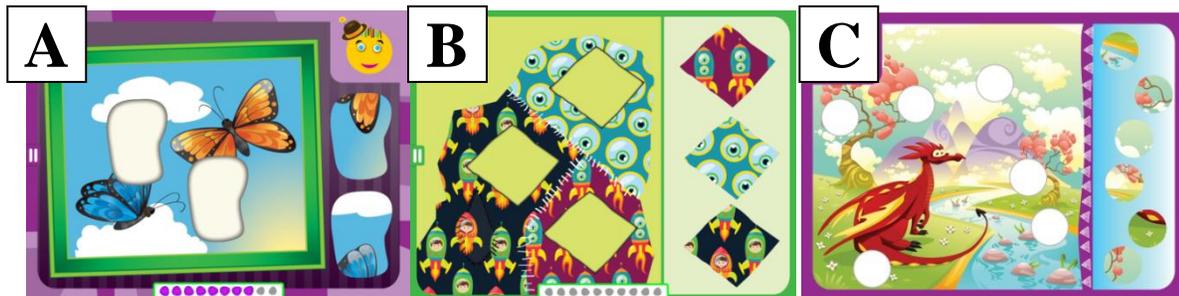


Figure S2. Patches activity.

(A) Easy: Level 2 (of 17);

(B) Intermediate: Level 9 (of 17);

(C) Advanced: Level 15 (of 17)

3. Matching Cars activity --- Developmental goal: attend to shape, color, and image details; perform multiple-cue responding, Beginner Game

The *Matching Cars* combines the two skills targeted by the *Outlines* and *Patches* games (attending to shape and color, respectively) and incorporates additional details on the inside and outside of the car, like drivers and luggage, for a child to notice. In the easier levels of the game, it is enough to notice only one feature of the target car, Fig. S3A-C. In more advanced levels, the game introduces **multiple cue responding** tasks, which require simultaneously attention to two or more features of a car, by including distractors that match the target along a single feature. For example, in Figure S3D, a child must notice BOTH the color and the shape of the target car.

Noticing only the green color of the target car will not be sufficient to find the correct match because there are two green cars among the choices. Similarly, noticing only the rectangular shape will also not be enough, as there are two rectangular cars to choose from, Fig. S3D. As the levels progress, the game becomes progressively more challenging by increasing the similarity as well as the number of distractors. In the final levels of the game, a child must attend to **four** features simultaneously: color, shape, the inside, and the outside of the car, Fig. S3E

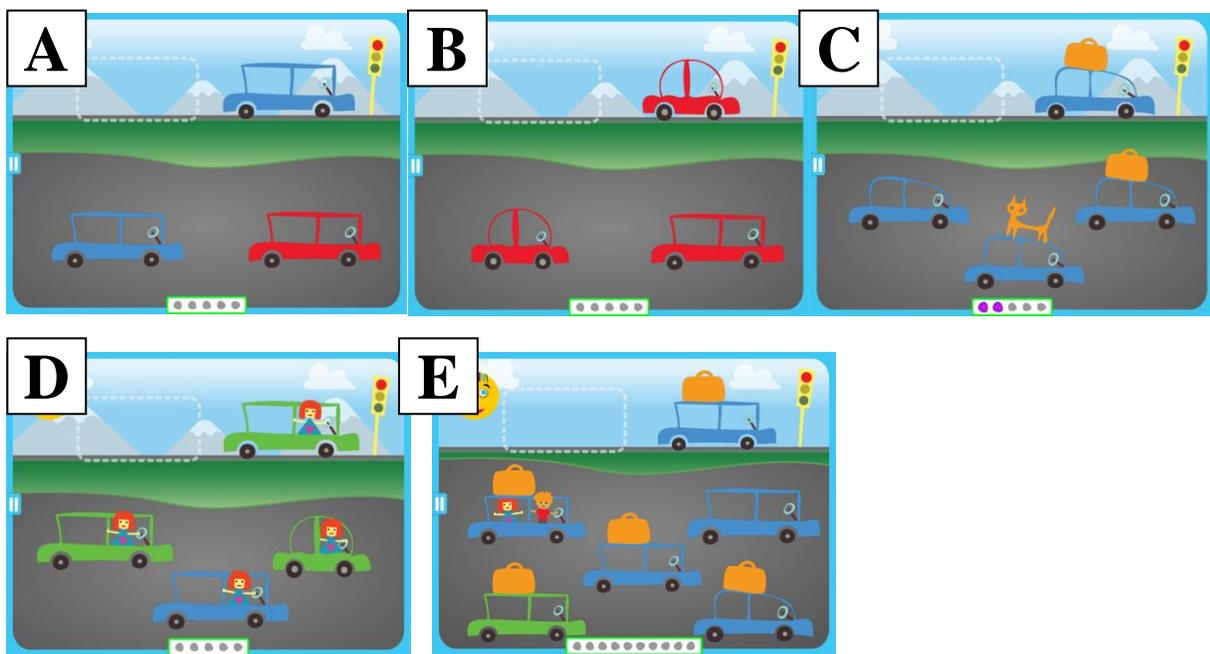


Figure S3. Matching Cars activity.

(A) Level 3: Notice the color of the car,

(B) Level 4: Notice the shape of the car.

(C) Level 11: Notice what's on top of the car.

(D) Level 14: Notice the color AND the shape of the target car.

(E) Level 49: Notice the color and the shape of the target car, as well as what's inside and outside

4. Matching Animals activity --- Developmental goal: attend to shape, color, size, and orientation; perform multiple-cue responding, Beginner Game

The *Matching Animals* game incorporates two additional features for a child to notice: size (Fig. S4A) and orientation (Fig. S4B). Eventually the game introduces multiple cue responding tasks, which require attending to two or more features simultaneously, by including distractors that match the target along a single feature, Fig. S4C-D.

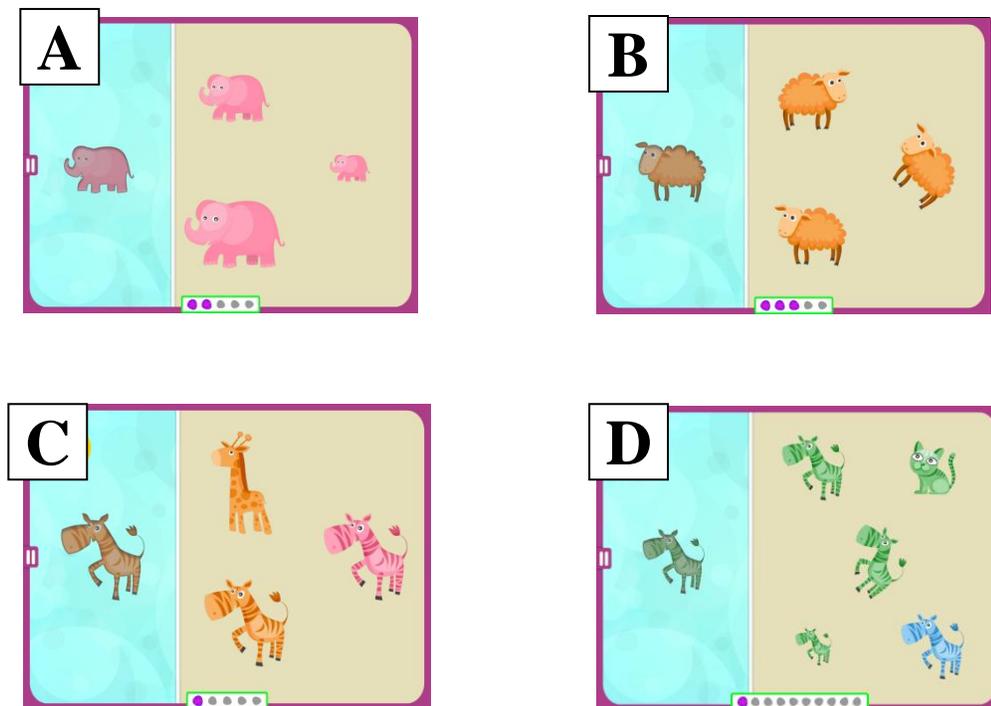


Figure S4. Matching Animals activity.

(A) Level 11: Notice the size of the target animal.

(B) Level 12: Notice which direction the animal is facing.

(C) Level 14: Multiple-cue responding: Notice the color and shape of the target animal.

(D) Level 49: Notice the color, shape, size and orientation of the target animal. Each distractor matches the target along a single feature.

5. Odd-one-out activity --- Developmental goal: attend to shape, color, pattern and orientation; perform multiple-cue responding, Intermediate Game

Our *Odd-One-Out* game reverses the matching paradigm of the previous games and instead requires a child to find the object that does NOT match any of the others, requiring attention to color, shape, pattern and orientation.

This game follows a typical odd-one-out scenario, starting with puzzles in which the “odd bug” differs from the others in color, shape, or orientation, Fig. S5A-C. As with the matching activities, Odd-one-out eventually requires attending to multiple cues by including distractors that match the target along a single feature, Fig. S5D-F.

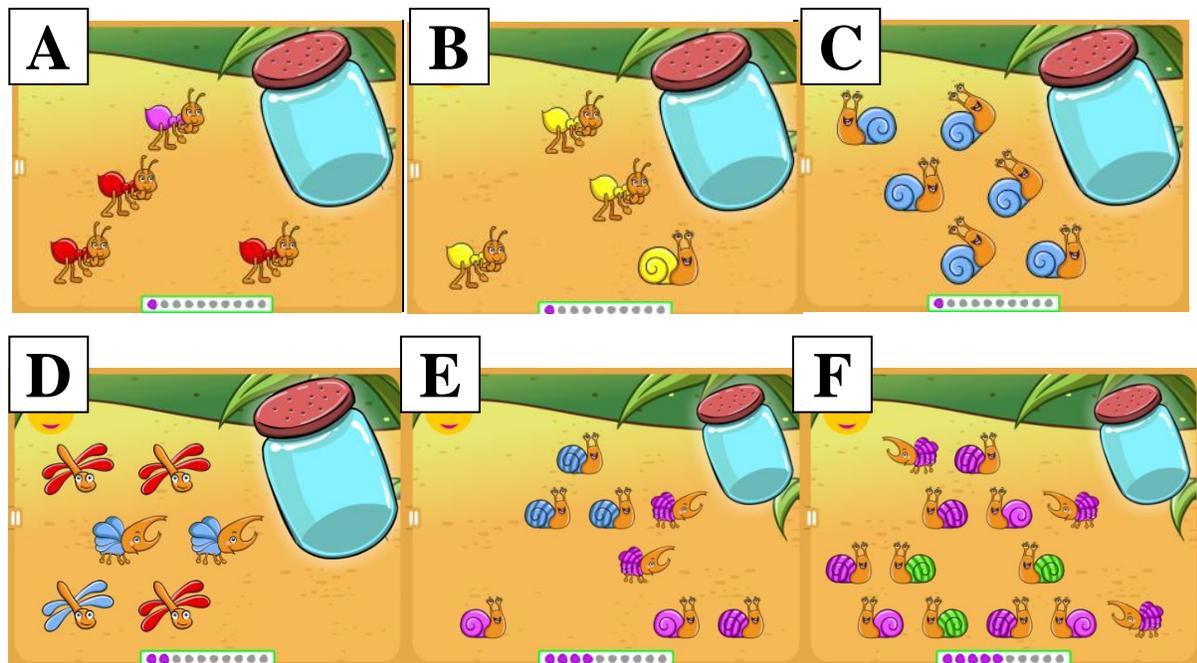


Figure 5. Find the bug that does not belong and place it into the jar.

- (A) Level 3: Notice the color.
- (B) Level 4: Notice the shape.
- (C) Level 17: Notice the orientation.
- (D) Level 19: Notice color and shape.
- (E) Level 32: Notice color, shape and pattern.
- (F) Level 49: Notice color, shape, pattern and orientation

6. Combine Elephants activity --- Developmental goal: mental integration, multiple-cue responding, Intermediate Game

The *Combine Elephants* game requires not only attending to a variety of different features but also the **mental integration** of separate images into a single gestalt. As in previous games, the distractors force a child to attend to a particular feature of the elephant, such as the color, shape and orientation of the body, as well as the color shape and details of the ear, Fig.

S6A-C. In more advanced levels, the distractors force attending to multiple cues. Fig. S6D-E.

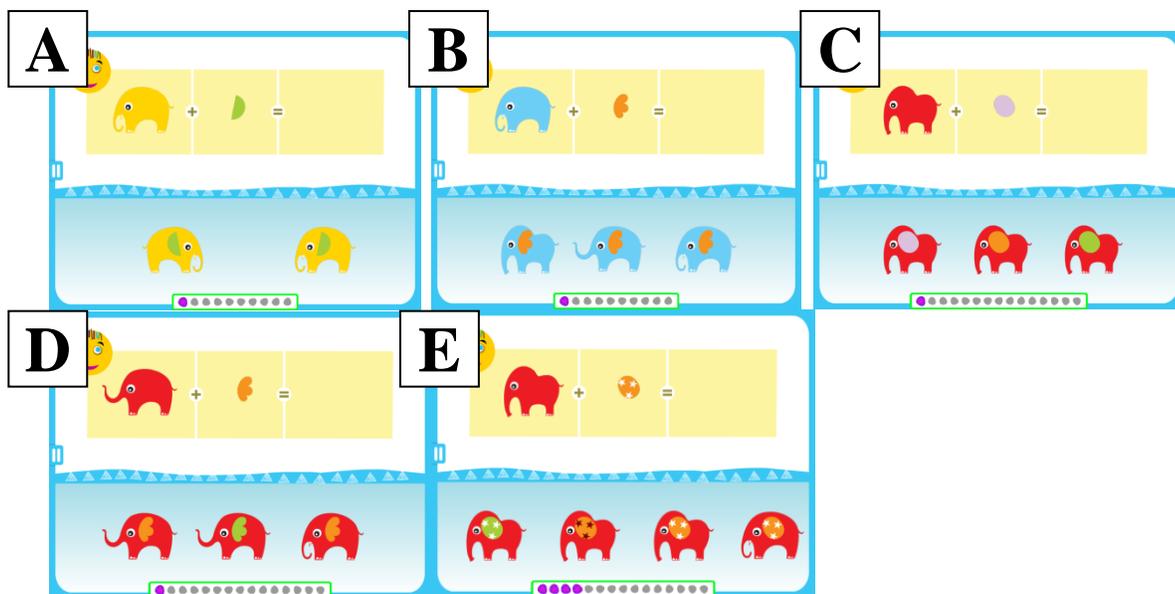


Figure S6. Find the correct complete elephant and place in into the empty square.

(A) Level 5: Notice the elephant's orientation.

(B) Level 12: Notice the shape of the body.

(C) Level 14: Notice the color of the ear.

(D) Level 20: Notice the shape of the body and the color of the ear.

(E) Level 49: Notice the shape of the body, the color of the ear, and the color of the star ornamentation

7. Combine Toys activity --- Developmental goal: mental integration, multiple-cue responding, Advanced Game

Combine Toys is MITA's advanced mental integration game, in which a child must combine various images within a grid. The game requires a child to notice position and orientation, as well as the different colors and shapes of the various toys. The *Combine Toys*

game also introduces a child to important elements of language: the spatial prepositions *in front*, *behind*, and *inside*. The initial levels of this game require the mental integration of up to . A child must find the correct combination from the choices on the bottom of the screen and place it into the single empty cell within the grid. In the example below, a child must look at the grid and notice the toy (a dinosaur) as well as the color of the car (yellow), and then mentally combine these two objects, resulting in the correct answer (a green dinosaur inside a yellow car), Fig. S7A-C. In the most difficult levels of this game, a child must notice not only the various features of all the toys and vehicles, but also the correct *positioning* of the toy, which is modeled in the top left cell of the grid. In Figure S7D, the example image in the top left cell of the grid indicates that all the toys in this puzzle must be placed behind the vehicle, while Figure S7E indicates that the toy must be placed in front of the vehicle.

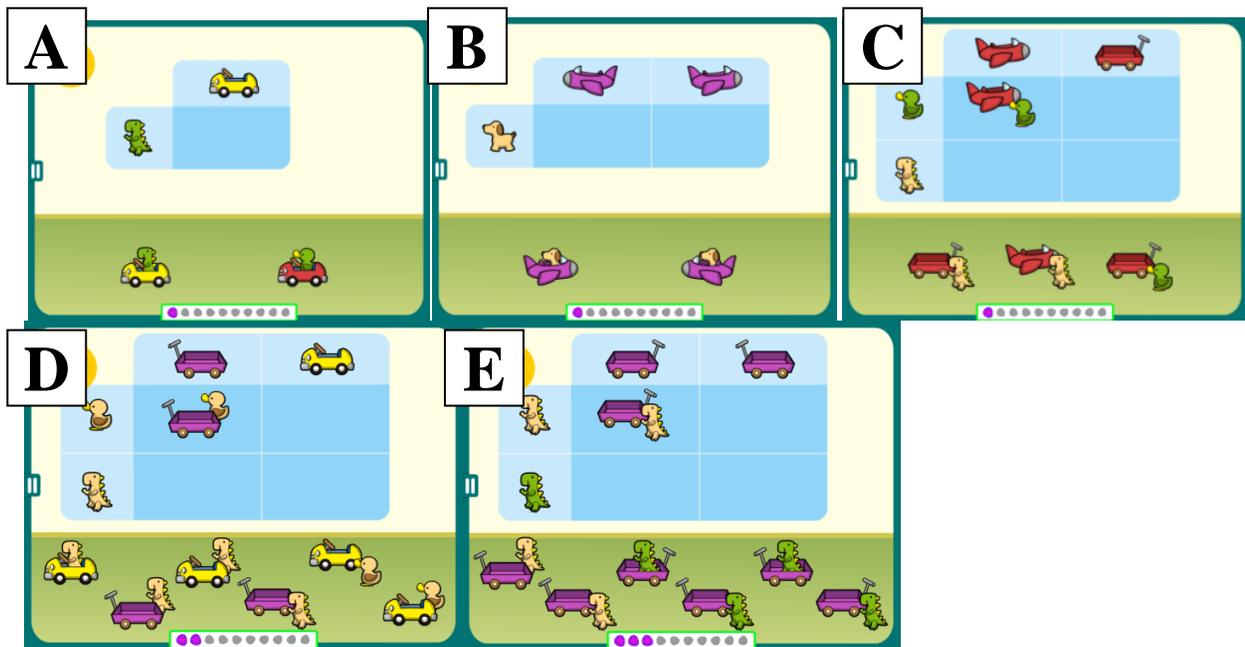


Figure S7. Find the correct combination of images within the grid and elephant and place in into the empty square(s).

(A) Level 10: Combine the green dinosaur with the yellow car .

(B) Level 20: Combine the dog with identical planes facing different directions.

(C) Level 30: Combine all the objects in the grid.

(D) Level 40: The toy should be placed behind the vehicle.

(E) Level 50: Notice the color of the dinosaur, the orientation of the cart, as well as the correct positioning of the toys.

8. Analogy activity --- Developmental goal: relationships and logic, multiple-cue responding, Advanced Game

In the *Analogy* game, a child must notice the relationship between the objects in the top row and then apply the same logic to the objects in the bottom row. Because this game requires not only attention but also logic, it is only recommended for older kids, or for ones who have shown steady progress with the other MITA games.

For example, in Figure S8A, a child must notice that the two red houses in the top row are mirror images, and complete the analogy by finding the mirror image of the purple house from the two choices at the bottom. The difficulty is increased by adding distractors that are similar to the correct answer and by making more complex and nuanced changes in the top row relationship. A child must figure out the logic, and discard the distractors to find the correct

A r, Fig. S8B-D.

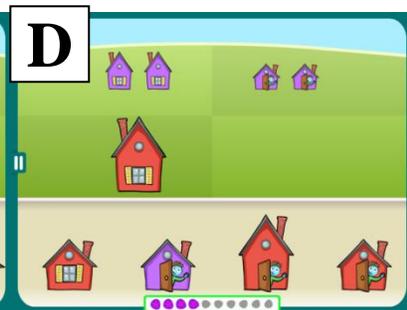
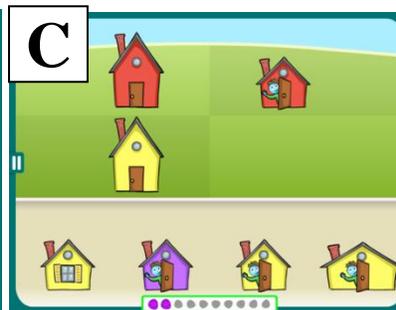


Figure S8. Analogy activity.

(A) Level 7: Notice the change in orientation in the top row.

(B) Level 30: Notice the change in color.

(C) Level 40: Notice the change of shape and added detail in top row.

(D) Level 50: Notice the color, shape, orientation and added details in the top row.

9. Language Game activity --- Developmental goal: multiple-cue responding and mental integration

MITA's *Language Game* trains a child's multiple cue responding and mental integration skills through a verbal approach. The *Language Game* offers a more conventional approach to facilitating language acquisition, starting with simple vocabulary-building exercises and progressing towards exercises aimed at higher forms of language, such as noun-adjective combinations, prepositions, and syntax.

The initial levels introduce a child to the ten common nouns (Dog, Cup, Ball, Car, Book, Table, Chair, Couch, Slide and Bed) that are used throughout the rest of the Language Game, laying the foundation for all subsequent learning. We have deliberately limited the exercises to only these ten nouns since the game's aim is NOT to expand a child's one-word vocabulary, but rather to teach a child to integrate previously-learned words in novel ways. The game goes on to teach and then integrate adjectives of size (small, large), color (red, blue, green, orange) and number (one, two, three) with all ten previously-learned nouns, Fig. S9A-C.

Once children have learned to integrate adjectives with all ten nouns, they face multiple cue responding task in which they must attend to BOTH the adjective and the noun in order to find the correct object. For example, when directed to "find the blue car" (Fig. S9D), a child must attend to BOTH the color (blue) and the object (car). Attending only to the word "car" may result in a wrong answer since there are two cars to choose from. Similarly, attending only to the word "blue" may also result in a wrong answer since there are two blue objects to choose from.

Eventually the game moves on to levels which combine multiple adjective descriptors, such as size and color (Fig. S9F), or size, color and number (Fig. S9G) with a single noun.

The final levels of the game introduce the spatial prepositions "on," "under," "in front

of,” and “behind.” A child may hear a request to “put the ball under the bed” and have to attend to the correct nouns, prepositions as well as the syntax in order to place the objects into the correct configuration. Finally, the game culminates with the most difficult levels which incorporate adjectives into the scene with commands such as “put the small ball in front of the red couch.”

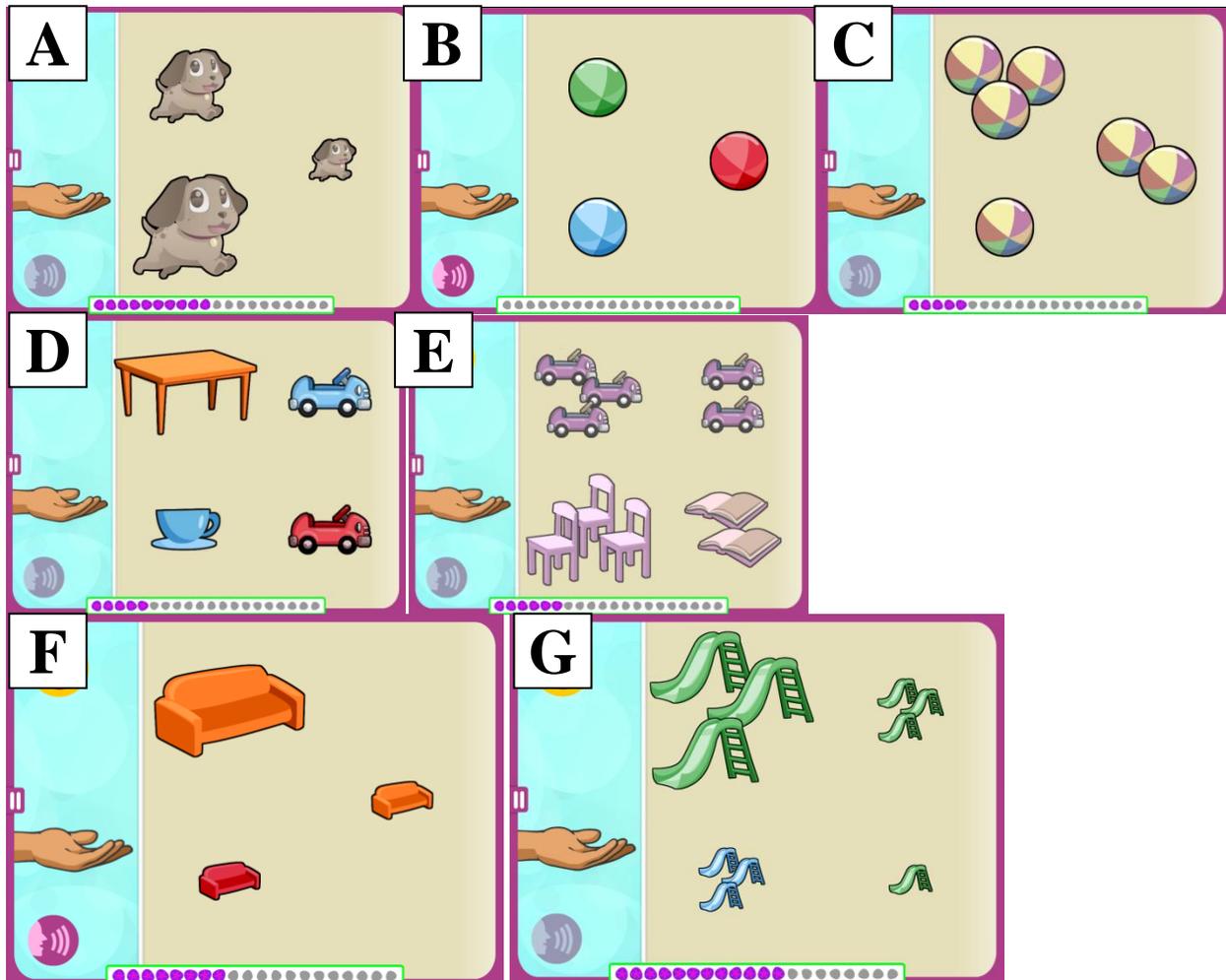


Figure S9. Integration of noun and adjectives for size, color and number.

(A) Level 45: Find the large dog.

(B) Level 67: Find the red ball.

(C) Level 86: Find two balls.

(D) Level 83: Multiple cue responding task: find the blue car with a blue distractor and a car distractor.

(E) Level 102: Find three cars with two distractors that match the target in either number or object.

(F) Level 112: Find the small, orange couch with one other small object and one other orange object as distractors.

(G) Level 156: Find the three, small, green slides where each of the distractors is similar to the target in two (of three) categories.