REMEMBERING BEYOND THE EDGES OF A VIEW: BOUNDARY EXTENSION IN PRESCHOOL CHILDREN AND ADULTS

by

Erica Kreindel

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Erica Kreindel

Approved: ____
Helene Intraub, Ph.D.
Co-Professor in charge of thesis on behalf of the Advisory Committee

Approved: ____
James E. Hoffman, Ph.D.
Co-Professor in charge of thesis on behalf of the Advisory Committee

Approved: ____
Robert F. Simons, Ph.D.
Professor and Chair of the Psychology Department

Approved: ____
George H. Watson, Ph.D.
Dean of the College of Arts & Sciences

Approved: ____
James G. Richards, Ph.D.
Vice Provost for Graduate and Professional Education

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This manuscript is dedicated to:

A true friend whose life was taken much too soon, during the preparation of this document. Jonathan G. Meyers' legacy was to follow ones heart, and that is one lesson that will stay with me forever.

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ABSTRACT

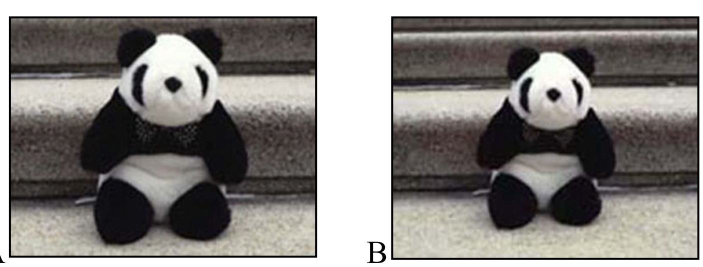
Boundary Extension (BE) is a memory error in which people remember seeing more of a scene than was originally viewed (Intraub & Richardson, 1989). The studies presented here were designed to test the hypothesis that preschool-aged children (4-5 year olds) experience BE. Experiment 1 used a drawing task in which children (N=29) and adults (N=26) viewed the same scene-photograph and then drew it from memory, revealing BE in both groups. Experiments 2 through 4 tested BE without relying on participants' drawing ability. Experiment 2 introduced a two-alternative forced choice recognition task in which children (N=26) and adults (N=26) were shown a photograph and upon its removal they selected which of two test photographs matched what they saw before (the choice always included the same view and a different view – either closer or more wide-angled). Errors usually involved selection of the wider view, signifying BE. In Experiment 3, this same task was modified to determine if children's (N=26) errors reflected a selection bias for the wider-angle view rather than true BE. The selection bias hypothesis was ruled out. In Experiment 4, the forced choice task (used in Experiment 2) was used with more complex multi-object scenes and showed that children (N=26) again, exhibited BE . Adults' (N=26) performance in Experiment 4, however was at ceiling; they rarely made errors – probably because the scene were more wide-angled than the single object views used earlier. However when the multi-object scenes were presented more briefly to adults (N=26), in Experiment 5, they too exhibited BE. A selection bias task was given to both children and adults (Experiments 4 and 5), and again, selection bias

was ruled out. Results from Experiments 1, 2, 4 and 5 indicated that like adults, children experienced BE and the two-alternative forced choice task (from Experiments 2, 4 and 5) can be used to answer other questions about scene and spatial memory with young children in future research.

Chapter 1

INTRODUCTION

Boundary Extension (BE) is an error of commission in which people falsely remember seeing beyond the boundaries of a view (Intraub & Richardson, 1989). After being shown a close-up view of a scene as in panel A of Figure 1.1, people will often remember seeing something more like in panel B. The fact that people remember part of the scene that was never visually presented (more of the staircase) suggests that scene-memory is not limited to visual representation (Intraub, 2012). BE is an interesting phenomenon because people do not seem to be able to create and retain an exact memory of what they have seen. Instead, they understand the concrete features of a symbol (the picture) and its relation to something else (the world) at the same time, otherwise known as dual representation (DeLoache, Miller & Rosengren, 1997). As a result, a picture is understood to be part of a continuous world and not simply as a piece of paper with shapes and colors on it. People often mistakenly remember what they saw, as quickly as 1/20th of a second after viewing (Intraub & Dickinson, 2008), and evidence provided here will shed light on why this spatial memory error may be a fundamental aspect of our spatial cognition

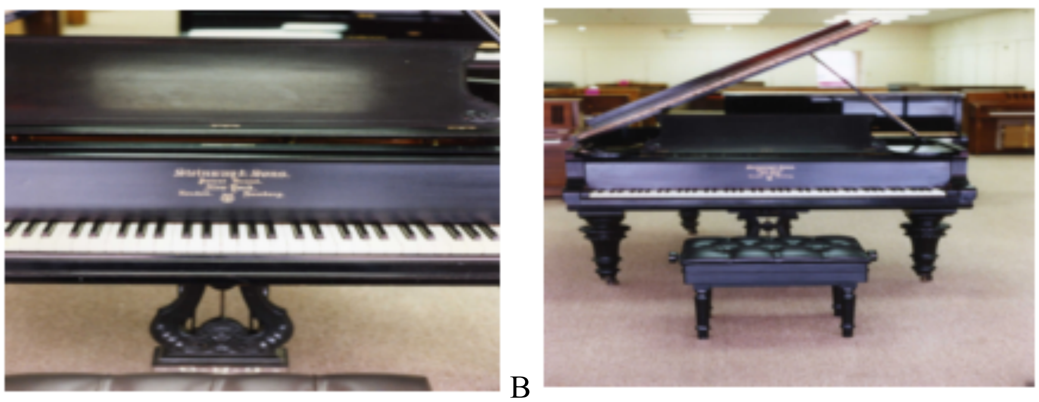


A B

Figure 1.1: Panel A displays a close-up view of a bear on some steps and Panel B displays a wider-angle view of the same scene containing more of the surrounding space (both vertically and horizontally).

Adults have been found to exhibit BE through various methods for measuring this phenomenon. However, understanding whether people experience BE differently throughout development could provide insight into changes that may take place in how they deal with dual representation and spatial perception. The youngest children tested for BE, using an explicit memory test, were six-years old (Seamon, Schlegel, Hiester, Landau, & Blumenthal, 2002). Explicit memory tests are those in which participants are asked to openly express (i.e. through verbal or illustrative report) what they remember. Seamon et al., (2002) set out to establish whether different age groups exhibited the same amount of BE by asking them to view photographs and then recreate them through drawing. Although Seamon et al., (2002) found developmental differences in BE, a methodological issue (i.e., drawing ability of children compared to adults) was never fully addressed. Consequently, it is not clear whether different age groups exhibited BE to the same extent and achieved dual representation similarly, or whether they have different drawing styles and similar memory. The main issue addressed in the current study was in replicating the findings that children exhibit more BE than adults (Seamon et al., 2002) as well as testing whether preschool-aged children's and adults' spontaneous drawings tells us anything about their drawings from memory, that raise concerns.

Dual Representation and BE may be worth investigating during the pre-school years. Liben (2003) conducted a study in which three, five, and seven-year old children were shown scene-pairs that differed in viewing distance (as in Figure 1.2 where the central object is a piano) but were not asked to remember anything. Results indicated that there was a progression in the number of children who could accurately explain that the photographer had to move closer or farther away from the central object in order to capture more or less of the scene. The three-year olds had a more difficult time than the five and seven-year olds when asked to discriminate between scene views (as seen in Panels A and B of Figure 1.2). Her work shows that the youngest children who readily understand camera distance are 4-year olds. Therefore, the current study tested whether this age group exhibits BE.



A B

Figure 1.2: Panel A displays a close up of a grand piano in a room and Panel B displays a much wider view of the same scene. This is an example of photograph-pairs that differ in viewing distance (described in Liben, 2003).

The purpose of the current study was two-fold: to determine if even younger children than ever before tested through explicit means (ages four to five years) make this constructive memory error, and to address problems with prior methodology (Seamon et al., 2002) used to assess scene-memory in children. Do preschool-aged children remember a picture as a discrete picture or do they remember it as part of a continuous world in the same way adults do?

Boundary Extension

BE is a fundamental aspect of our spatial cognition (Intraub, 2012), and will be further explained in this section. As previously stated, BE is a false memory for the continuation of a view. Upon viewing the close-up view of the panda in Figure 1.1 panel A, one can clearly see how much of the staircase is visible, but also understands that this is or was an actual scene, and that the staircase is likely to exist beyond the picture's boundaries. The Multisource Model (Intraub, 2010, 2012; Intraub & Dickinson, 2008) includes two stages of processing that can explain why we are so likely to commit this unidirectional memory error. The first stage is the development of a multisource representation: input is received visually as well as through other sources, which include amodal continuation, surface interpolation (Kellman & Shipley, 1991), layout extrapolation, and world knowledge. As a result, this representation becomes organized within a spatial framework, allowing us to understand that space exists beyond the boundaries of a view. For example, one would likely assume that the staircase in Panel A is located outdoors, and that it most likely extends far beyond the boundaries. Our spatial framework helps us understand the surrounding world while viewing a scene, and the visual input from a photograph is but one source of information that is organized within this structure (Intraub, 2012).

The second stage of processing described by the Multisource Model (Intraub, 2012) involves memory for the original view and confusion regarding the source of the non-visual information; referred to in the literature as a source monitoring error (Johnson, Hashtroudi, & Lindsay, 1993). According to Johnson et al.'s (1993) framework, memories may come from different sources (perception, dreams, imaginations, etc.), and do not have labels indicating how they were acquired (i.e.

which source they came from). Instead, we attribute the source of a memory based on its qualitative characteristics (i.e. type and amount of perceptual detail) and our memories differ along these dimensions. In general, telling the difference between something we dreamt and something we saw (source monitoring) is very easy. However, if the dream is very clear and detailed (similar to a perception in terms of quality), we may not mistakenly attribute memory for the dream to perception. When deciding whether an event was dreamt or seen, the co-temporal events are evaluated and sometimes confused, increasing the likelihood of committing a source monitoring error.

In the case of BE, the qualitative characteristics are difficult to differentiate, leading to a source monitoring error. When looking at Figure 1.1 Panel A, one can clearly see that the bear's ears are very close to the photograph's edges. This should be fairly easy to remember. In addition, amodal perception continues the surfaces and top-down processing provides expectations about the extension of steps and other aspect of the likely surrounding world, allowing us to perceive the picture within a larger context. Then, at test, a source monitoring error occurs when people accept the imagined continuation as actually having been seen before, as in Figure 1.1 Panel B.

Research supporting the first stage of processing, the idea of a spatial framework that is filled in by multiple sources of information (i.e. amodal continuation, layout extrapolation, world knowledge), has come from a variety of studies using two-dimensional pictures. In particular, the early studies on BE tested this memory error for simple (single-object) scenes (Intraub & Richardson, 1989; Intraub, Bender & Mangles, 1992; Intraub & Bodamer, 1993; Intraub & Berkowitz, 1996; Intraub, Gottesman, Willey & Zuk, 1996; Intraub, Gottesman, & Bills, 1998), as well as complex scenes (Gagnier & Intraub, 2012). However, there have been studies demonstrating that BE is not limited to the visual modality and that it is not limited to two-dimensional pictures either (Intraub, 2004). In this section I provide evidence that BE is not only a spatial error, but also a fundamental aspect of our spatial representation and that it illustrates the nature of dual representation.

There is evidence to suggest that BE is not limited to the visual modality, and that input received in the first stage of the multisource model (e.g., surface interpolation) also occurs following exposure to three-dimensional scenes. Intraub (2004) found that participants exhibited BE for three-dimensional scenes in the same way they did for pictures. In addition, participants exhibited BE after exploring these scenes through haptic exploration alone (feeling three-dimensional objects through touch in an enclosed location while blindfolded). This suggested that the processes involved in BE are not limited to two-dimensional views of the world or to the visual modality. In addition, Intraub (2004) investigated what scene memory would be like for KC, a young woman who had been blind and deaf since early childhood. KC was limited to haptic exploration in her daily interactions with the world, and would be considered a "haptic expert" in the same way that the normally sighted participants used vision as their primary source for spatial exploration. If normally sighted participants exhibited BE when blindfolded, then it might have been due to an imagined visual memory for what was felt. However, if KC exhibited BE similarly to the blindfolded individuals, then it would have been due to haptic, and not visual, memory. Normally sighted participants not only exhibited BE when viewing three-dimensional scenes, but when blindfolded they and KC experienced the same amount of BE. These results suggest that BE may be an underlying aspect of spatial representation and not limited to the visual modality, in that it occurs for two and three-dimensional truncated views of the world, regardless of primary modality (vision or haptic exploration).

The occurrence of BE following memory for a scene that was not viewed, but felt, also indicates something important about the visual representation of space. KC, being blind and deaf, lacked visual experience but still exhibited BE through her primary sense (touch) in a world that was not visual. In addition, sighted participants exhibited the same representational error after feeling the world with their hands. Together, these results suggest that our minds are constantly predicting what lies beyond the boundaries, in both vision and touch. As a result, studying BE is a convenient way to question the nature of dual representation very directly. If participants predict what exists beyond the boundaries, then they are representing what they see and feel in space, as part of a continuous world, and not simply as individual symbols that stand-alone.

In addition to BE occurring in both the visual and haptic modalities, it has also been found to occur following memory for imagined backgrounds (Intraub, Gottesman, & Bills, 1998; Gottesman & Intraub, 2002). Intraub et al. (1998) presented two groups of participants with pictures of the same outline objects on a blank background (lacking a scene-context), and asked them to remember them to the best of their ability. Each object had been traced from a photograph (by the experimenter) and appeared on a plain-white background. One of the groups was asked to also imagine a background, described by the experimenter, while the other group simply remembered the outline object and did no imagination-task. Figure 1.3 contains one of the outline-pictures used in this experiment, described as “a black office chair on a stone walkway in front of a large stone wall that fills the picture space." The authors hypothesized that imagining scenes would recruit the same processes that take place during scene perception. The Multisource Model (Intraub, 2012) would describe these processes today as having activated participants' spatial framework. If imagining the scene activated the participants' spatial framework, then the group given the scene-descriptions would exhibit BE and the group that was not given a scene-description should not. Results indicated that only the imagery group exhibited BE, suggesting that memory for more surrounding space, occurred following scene-imagination.

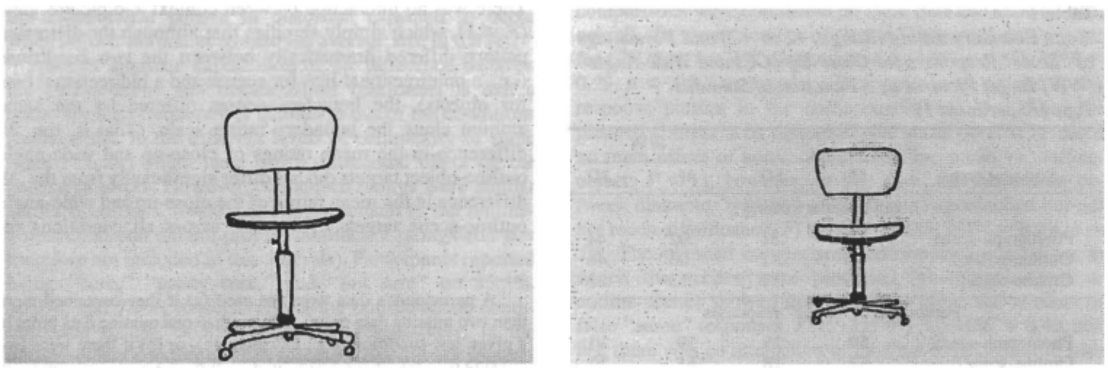


Figure 1.3: An example of an outline-object scene used (Intraub, Gottesman & Bills, 1998). The imagination-group likely remembered the scene to the right (containing more imagined space).

Similarly to BE occurring in vision and touch, participants who imagined a background predicted what was likely to lie beyond the boundaries of imagined space. They represented the imagined scene as a likely location in space, and not limited to two-dimensional symbols. However, upon viewing the outline objects alone, participants perceived them only as symbols, and not as part of a scenic representation. Participants who had exhibited BE for the imagined scenes, had apparently represented them as locations in space in the same way they would for viewed scenes.

In support of the first stage of the Multisource Model (Intraub, 2012), there is research showing that BE occurs in vision, touch, and the imagination of scenes. A common factor in all of these cases is an underlying spatial framework that can support multiple sources of input. Neuroscience provides us with another route for thinking about the spatial underpinnings of scene representation. For example, hippocampal activity has been associated with spatial navigation and scene construction (Hassabis & Maguire, 2007), the Parahippocampal Place Area (PPA) responds to viewing scenes (Epstein & Kanwisher, 1998) and the Retrosplenial Cortex (RSC) responds to scene-layout and is used for navigation (Maguire, 2011). Park, Intraub, Yi, Widders & Chun (2007) investigated how the PPA and the RSC are involved in BE. Using event-related functional Magnetic Resonance Imaging (fMRI), they found responses in both the PPA and the RSC seconds after viewing scenes. This indicated that high-level mechanisms were actively involved in extrapolating spatial layout beyond the scene's borders. In addition, recent research has shown that the hippocampus is directly involved in the initial and rapid extrapolation of scenes that takes place during BE (Chadwick, Mullally & Maguire, 2012). Therefore, the brain-areas that are involved in spatial perception become activated shortly after scene presentation, and truncated views (e.g., scene photographs) of the world become represented as part of a continuous world.

The hippocampus is also involved in imagination of events laid out in space (Addis, Wong, & Schacter, 2007), and damage or removal of this area may affect scene imagery and, as a result, BE. Hassabis, Kumaran, Vann & Maguire (2007) found that when asking patients with bilateral hippocampal lesions to imagine new scenes, their verbal reports lacked spatial coherence. They were able to think of an object and a scene-context, but were unable to imagine them in spatial relation to each other. Therefore the authors concluded that the patients could not successfully produce an imagined scene.

Another group of researchers (Mullally, Intraub, & Maguire, 2012) hypothesized that if patients with bilateral hippocampal lesions were not able to create an imagined scene, then perhaps the lack of spatial imagination would limit the amount of BE in memory. Although these patients would understand the dual representation nature of a scene, perhaps their spatial framework would be less activated beyond the boundaries of the view. Mullally et al., (2012) tested a group of patients with bilateral hippocampal lesions and amnesia, along with a group of controls using three different tests of BE. All participants completed a scene-presentation task (in which they rated briefly presented pictures as closer or wider than the each other), a drawing test (the same test and stimuli used in the present study in which they drew scenes from memory), and a haptic test (in which they explored a three-dimensional scene through touch, and then recreated where the original borders lay). Results indicated that the patients, who had trouble imagining a coherent scene, also had trouble imagining new surroundings. As a result, patients exhibited less BE on the brief presentation and drawing task, than the controls, and had accurate memory (no BE) in the haptic exploration task. If people lack the ability to perform cognitive processes as proposed by the Multisource Model's first stage (Intraub 2012), and perceive a coherent surrounding world, then the second stage (source monitoring error) should be very limited. Consequently, people would not experience a complete spatial representation.

Taken together, these studies show why BE reflects a spatial rather than simply a visual representation. This constructive memory error occurs following presentation of scenes through vision, touch, as well as imagination, indicating that it may be adaptive in allowing us to anticipate upcoming space. The tendency to anticipate space beyond the boundaries of a confined view has been shown to be a fundamental aspect to spatial cognition because it occurs regardless of modality, and as a result of a healthy spatial representation. Damage to an area involved in spatial representation (the hippocampus) reduced BE, limiting creation of a coherent multisource representation (Mullally et al., 2012). In sum, studying BE and the modalities through which it occurs, can help us understand other processes involved in spatial cognition as well as the achievement of dual representation.

Why is BE worthwhile to study in children?

BE has been used to study many aspects of cognition such as visual imagery (Gottesman & Intraub, 2002), the function of specific brain areas involved in spatial representation (Mullally et al., 2012), and visual versus haptic exploration of space (Intraub, 2004). In addition, BE is a useful tool for indicating that dual representation (DeLoache et al. 1997) is achieved following scene viewing for adults because they perceive a continuous world (Intraub, 2012). In this section I discuss the value in establishing whether or not the same spatial memory error that adults experience, also occurs for children.

As previously mentioned, a number of researchers have investigated whether children and adults similarly understand the dual nature of a photograph – that is both an object and a representation of something else (DeLoache et al., 1997; Liben, 2003;

Lillard, Lerner, Hopkins, Dore, Smith & Palmquist, 2012) but there has yet to be further evidence. Liben (2003), for example, discussed our tendency to interpret pictures as more than symbols but rather as representations of scenes and objects. In particular she discussed development of this ability and the importance of knowing the role of dual representation. Similarly, spatial abilities such as mental rotation and perspective taking also change throughout development and have an important role in the application of thinking related to science, technology, engineering and mathematic (STEM) disciplines (Newcombe & Frick, 2010). Because BE is a convenient way to test spatial thinking as well as dual representation, it may be an important tool for testing whether these underlying cognitive abilities occur early in development.

BE has been found to occur, through implicit means, as early as during infancy (Quinn & Intraub, 2007). This indicated that during this developmental stage, they understand the dual representation of pictures. Implicit tests are those in which memory is assessed without direct explanation from the participant. Quinn & Intraub (2007) investigated whether preverbal (3- to 4 and 6 to 7-month old) infants experienced BE through the use of an implicit memory task. By measuring the amounts of time infants spent looking at two visual displays, they were able to test spontaneous preference for one of the images. If infants spend a longer amount of time looking at one image, then they are believed to have a preference for it, and they frequently prefer what is novel.

In particular, Quinn & Intraub (2007) sought to test whether infants had a spontaneous preference for close up or wide-angle views of the same scene, and subsequently whether they exhibited BE after being familiarized to a standard (middle) view. If infants had no spontaneous preference, and exhibited BE, then after being familiarized to the standard view their memory for the scene should include more of the background. As a result, the close-up view would then be considered novel, and they would spend longer looking at it. If infants do not exhibit BE, then they would spend the same amount of time looking at the close up and wide-angle view after being familiarized with the standard view. Results suggested that both groups of infants exhibited BE..

The purpose of the present study was to determine if preschool-aged children (4-5 years old) exhibit BE, and whether they exhibit more or less than college-aged (18-22 years old) adults. Both would be determined through the use of two drawing tasks and a novel two-alternative forced-choice test. In the tasks used to evaluate BE in adults, participants are shown a photograph of a scene, and are asked to remember it to the best of their ability (Intraub & Richardson, 1989; Intraub, Bender & Mangels, 1992; Intraub & Dickinson, 2008; Intaub et al., 2008). After a given amount of time, they are shown exactly the same view again, but asked to indicate whether they remember it as closer, wider, or the same view as the one previously depicted. If participants experience BE, then they recall having seen a more wide-angle view and therefore say the same view (that was shown previously), is closer up and includes less space. Although the scenes shown during a BE task, are not shown together (as they were in Liben, 2003), participants have to understand the spatial concepts involved when including more or less of the scene. Therefore, a first step would include seeing whether children in fact notice a difference between both views.

Another reason in testing whether 4-5 year old children exhibit BE is because at this age they are prone to source monitoring errors like adults (Foley, Johnson & Raye, 1983; Lindsay, Johnson & Kwon; Lindsay, 2008). As previously stated, according to the Multisource Model (Intraub, 2012), BE is a type of source monitoring error. Therefore explicit memory tests, such as those used to determine if children are prone to source monitoring errors, may be used with this age group. The various methods used to address BE in adults are very complex, and the next section will go into depth explaining why, and how the current study was designed to account for them.

Methodological issues involved in testing BE with young children.

As previously mentioned, BE has been studied across modalities as well as at different developmental stages. However, the majority of BE studies have tested spatial memory through use of the visual modality in the adult population. In this section, I will discuss the methodological issues that exist when testing BE, as well as when testing preschool-aged children. In addition, I will discuss how these issues were accounted for in the current study.

The most common method for testing BE in adults was briefly mentioned in the previous section. It is called the camera distance paradigm (Intraub & Richardson, 1989, Intraub et al., 1992). In this procedure, participants tried to remember all aspects of a photograph scene and after its removal were then presented with a second view, which, unbeknownst to them, was the same photograph they previously observed. Participants had to indicate if the camera was in the same location, “slightly closer”, “much too close,” “slightly farther,” or “much too far away,” on a 5-point scale. In order to describe what they remembered, participants were shown closer and wider views, and were instructed to compare the view in memory with the present view. The nature of this rating task included studying the relative sizes of the objects and background, as well as understanding how they were affected by camera distance when the picture was taken. Explaining these instructions, as well as asking them to compare degrees of BE may be too complex for very young children (Chapman, Ropa, Mitchell, & Ackroyd, 2005). For example, the closer and wider views of the teddy bear on the steps (in Figure 1.1) are pictures of the same teddy bear in the same location. If asked whether these two are the same or different, this question may be confusing because they essentially both share the same objects (i.e., panda bear and staircase). For this reason, a complicated task which involves further explaining how much closer-up or wider-angle they are to each other, may be too complex for children who already had trouble explaining the actions taken by a photographer to make both a close-up and wide-angle view of the same scene (Liben, 2003).

There have been other tasks, however, that did not involve understanding how object size was affected by camera distance. The loom-zoom task used by Chapman et al. (2005) is a computer task that was used to test BE in adults (aged 18 and older) and children (aged 9-16). In this task, participants used a computer key-press to manipulate (by zooming in or out) the amount of magnification on a scene-image in order to make it resemble the original photograph. The border adjustment task involved another similar computer method, used by Intraub, Hoffman, Wetherhold, & Stoehs, (2006) to test BE in adults (aged 18 and older). Intraub et al. (2006) asked participants to use a computer mouse in order to manually adjust where they remembered all four of a scene's borders. For both of these tasks, there may be problems with showing participants, and particularly young children, multiple views of the same picture until they select the one that best matches the scene in memory. This may cause confusion over which scene was the original. In addition, manual control over scene borders and camera-zoom may be too distracting for preschool-aged children because they involve complex computer capabilities, and the zooming-action may reduce how serious children interpret the task because they may view it as a game rather than trying to use it to match their representation.

The drawing task has been a commonly used test of free recall, in order to determine what they spontaneously remember (Intraub & Richardson, 1989; Intraub & Bodamer, 1993; Intraub & Berkowitz, 1996; Mullally, Intraub & Maguire, 2012). This task has had the benefit of simple instructions and no practice trials: asking participants to draw a scene exactly as they remember it. Experimenters measured the size of the objects in the original scenes and compared them to the area covered by the drawn object, related to the size of the object in the original scene. Unlike rating tasks, participants did not have to judge the similarity between different views of the same scene, and did not have to adjust a scene's zoom or borders to resemble its original appearance. However, two important problems with drawing tasks are difficulty distinguishing participants' memory from their artistic ability as well as possible conventions in the way they draw (Intraub & Richardson, 1989). For these reasons, studies that have used drawing tasks to test BE in adults, have also provided converging evidence for BE by including a task that did not require drawings, such as the camera-distance paradigm mentioned earlier. Because of the difficulties inherent in the camera-distance tasks, neither Seamon et al. (2002), nor Candel et al. (2008), who both tested children, used an additional task in order to find converging evidence of BE. Although the drawing task is easy for children and is purely a test of free recall, no study using it to test children for BE has used another task such as the camera-distance paradigm in order to establish converging evidence for BE.

Seamon et al., (2002) made developmental comparisons of BE by looking at the relative amount of space occupied by the central object relative to the whole scene (first graders, fifth graders, college students, and older adults). Because BE is about remembering more surrounding space than was originally present, the authors measured the size of the drawn main-object. They believed they could infer how much of the background a participant remembered in the original scene, as was previously done in adult BE studies. If participants exhibited BE, then they drew more of the background, and consequently a smaller-sized object. If an age group drew smaller-sized objects, compared to another age group, then they were believed to have exhibited more BE.

All participants in Seamon et al.'s (2002) study exhibited BE because they drew the central objects a smaller size than the object in the original photograph. In addition, the authors concluded that the children exhibited more BE than the college-aged adults; children drew smaller objects and included more of the background. However, a potential issue was raised regarding this conclusion: perhaps children's smaller objects did not reflect BE and instead a tendency to draw smaller objects for a different reason (e.g., smaller hands). In order to address this issue, Seamon et al. (2002) pointed out that if children simply drew smaller objects, then everything, including the background in their drawings should be smaller. They argued against this possibility by analyzing drawings of a picture that included quantifiable objects in the background (floorboards) to determine if participants remembered the same number of boards, but simply drew them smaller. However, in those drawings children drew more of the floorboards than adults, suggesting that they remembered a greater, more expansive background.

As previously described, the most frequent means of testing BE in young children has been the drawing task (Seamon et al., 2002; Candel, Merckelbach, Houben & Vandyck, 2008) due to its simplicity compared with the other methods. However, there are developmental differences in how children draw (Jolley, 2010), and comparing drawings of the same object across developmental stages, should be done with caution. Figure 1.3 provides an example of this, the classic "tadpole" drawing made by young children to represent people. The people in the drawings, realistically, could never have arms and legs coming out of their heads. If children at this stage of development and adults were asked to draw the same people, it would not be appropriate to say their memory differed based on drawn recreations. The drawings might reflect developmental differences in technique, and not memory for people having legs stemming from their heads. For this reason, developmental differences must be controlled for when using a drawing task such as this one by evaluating innate drawing tendencies amongst age groups. In addition, using converging operations that do not involve drawing may be especially important when testing preschool-aged children with a drawing task in order to establish whether they exhibit BE at all.

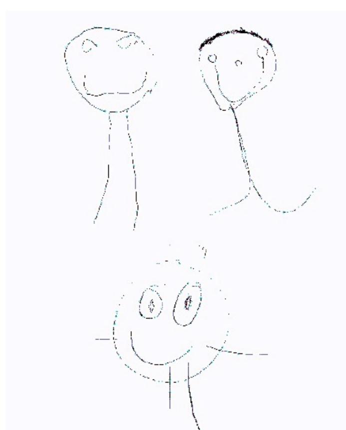


Figure 1.4: Three tadpole-drawing examples illustrate commonalities in young children's abilities that differ from adults' (Jolley, 2010).

In view of these concerns, the current study tested whether a younger age group than ever tested through explicit means (4- to 5-year olds), exhibited BE. In the following five experiments children and adults completed a drawing task, a matching task and a Guessing Game task. Adults were included in order to verify that these tests are in fact capable of detecting BE in a population already known to exhibit it. For the drawing task (Experiment 1), a control (spontaneous drawing task) was designed in order to account for the possibility that this age group might draw objects a certain size regardless of the task assigned. If 4- to 5-year olds exhibited BE as the 6-year olds did (Seamon et al., 2002), then they would also draw the main-object a smaller size than in the photograph. In addition, another test would determine converging evidence for BE in this population.

The present study also developed a new method in order to establish whether children exhibited BE through a task that did not involve drawing (Experiment 2). This was designed to test children's memory very quickly (after 2 s) through a matching task that was well within their capabilities. Unlike the preferential looking task used by Quinn & Intraub (2007), this was an explicit test of scene-memory. The children could indicate which of two scenes they remembered viewing (for 15 s). This task was different from the camera-zoom and border-adjustment tasks because participants did not have to see multiple views before deciding which was the original. They simply saw the same view along with a closer or wider view and if they mistakenly remembered seeing a wider view than the original, then they exhibited BE. If they exhibited BE, they would select the wider-angle view at a higher frequency than the close-up view.

In order to verify that children did not select the wider-angle view more often because they preferred it but rather because they remembered it as such, a Guessing Game task (Experiment 3) was designed. In each trial of the Guessing Game task, children were shown two views of the same scene (close-up and wide-angle) and were asked to simply choose which view they believed was being concealed. The subsequent two tests examined whether these age groups exhibited BE for the same complex scenes that contained multiple objects (Experiments 3 and 4). Furthermore, the methodology described may provide useful for future studies when testing and comparing different developmental age groups, and drawing inferences on these fundamental underlying cognitive abilities.

Chapter 2

EXPERIMENT 1

The purpose of Experiment 1 was to determine whether preschool children would exhibit explicit BE through drawings. I sought to replicate findings from Seamon et al. (2002) in which older children exhibited more BE than adults. I also designed a separate task, the Spontaneous Drawing Task, in order to address the possibility that children may simply draw smaller objects than adults, and to compare both groups. If children and adults were asked to draw an object (not a scene from memory), and children draw smaller objects, then comparing children and adults' scene-drawings would not indicate that children exhibited more BE than adults. If children were capable of drawing larger objects but drew smaller in a Memory Task, remembering a more expansive scene, then that would strengthen the evidence for BE in this age group.

2.1 Method

2.1.1 Participants

Thirty children (12 females) between the ages of 4 to 5 years from the University of Delaware's Early Learning Center participated in this study. One child (female) did not complete the task, thus the data include drawings from 29 children (M=4.66 years, SD=0.35, Range=4.14-5.30 years). Twenty-six University of

Delaware undergraduates (19 females) participating in the general-psychology subject pool (M=18.69 years, SD=0.93, Range=19-21) took part as well and were compensated with course credit.

2.1.2 Stimuli

Stimuli were two photographs of natural, everyday scenes. One stimulus of two children on a swing set was used to acclimate participants to the task at hand prior to the task. I wanted the children to understand that the task was to remember all aspects of the scene (main objects, background, etc.) up to the edges of the photograph. The stimulus for the memory task was a close-up photograph of a basketball on a wooden surface with a white wall behind it.

2.1.3 Design and Procedure

For all experiments in this study, children were run in a testing room located at the Early Learning Center and adults were run in a lab located at the University of Delaware's Psychology Department.

Participants were first presented the photograph-scene containing two girls on a swing set and asked to point to all four edges. This was done to ensure that participants knew that that the experimenter referred to the edges of the picture, and not the edges of the piece of paper. Participants also described the scene up to the edges, and when the experimenter took it away, they were asked to recall every part of the scene to the best of their ability. Next, participants were presented with an "empty picture" and asked to again point to the edges. In this spontaneous drawing task all participants drew a "nice big round happy face" within this empty scene using Crayola Crayons that had been pre-selected for brightness so they would be visible during analysis.

Upon finishing their spontaneous drawing, participants were presented with a photograph of a scene (for 15 s) containing a close-up view of a basketball on a hardwood floor with a wall behind it. Immediately after its removal (approximately two seconds), they were again presented with an empty-picture where they could recreate (draw) all parts of the scene to the best of their abilities with a choice of the same Crayola Crayons used for the previous task. Instructions remained consistent for all participants, asking them to recreate the photograph of the "nice, big round basketball." Both groups completed these drawing tasks (spontaneous and memory) within the a single testing session lasting approximately 20 minutes for children and 10 minutes for adults.

2.2 Results & Discussion

Results from the memory test revealed that both groups remembered having seen beyond the edges of the view. Specifically, children's drawings suggested that they exhibited BE because they drew a more expansive scene than was present in the original photograph. Figure 2.1 includes the original photograph (Panel A) as well as examples of both children's (Panel B) and adults' (Panel C) drawings of the same scene. I determined that in fact they drew more expansive backgrounds by measuring the sizes (number of pixels using the Polygonal Lasso Tool in Adobe Photoshop CS5) in the selected main objects drawn and comparing them to the number of pixels in the original main object (from the photograph). I divided the number of pixels in the main-objects (of both children and adults' drawings) by the number of pixels in the original basketball. The resulting proportion revealed the extent of reduction that occurred in memory.

Figure 2.1: The original photograph participants tried to remember (Panel A) and examples of drawings that represent the mean from each group (Panels B and C).

Figure 2.2 shows the mean proportion drawn for each group (error bars signify the 0.95 confidence intervals), compared to the original. As can be seen in Figure 2.2, both groups showed ratios significantly less than 1.00, indicating that the main object took up less of the space in their drawings than in the original picture Results from the present memory test replicated Seamon et al., (2002) because children drew smaller objects and a more expansive background than adults.

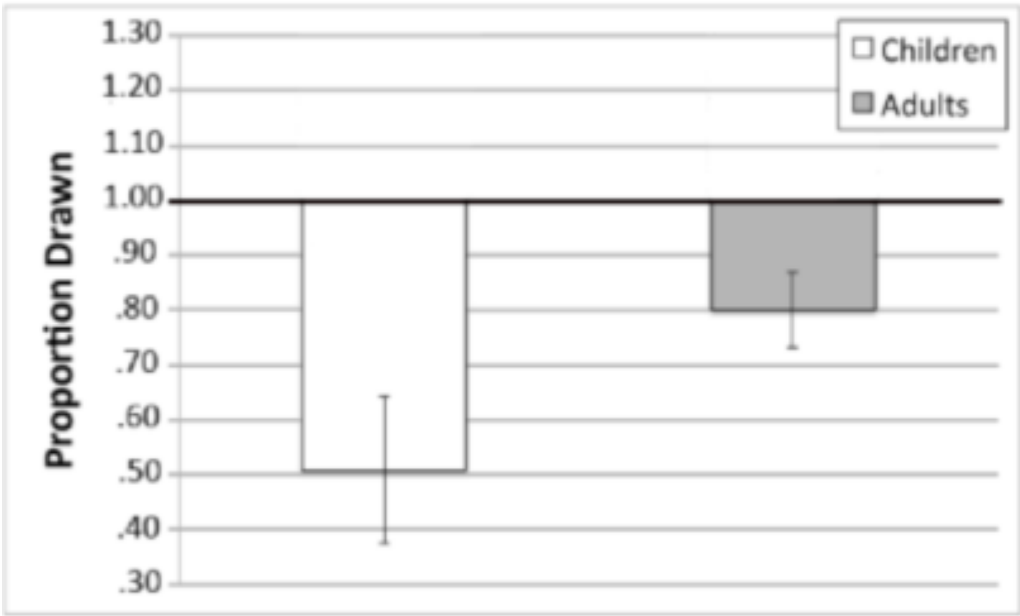


Figure 2.2: Mean proportion of the original space covered by the basketball in the drawings. Object drawn by each group, as a function of the size of the original basketball. Error bars represent 95% confidence intervals around each mean. BE occurs when the mean proportion drawn is significantly less than 1.00, (i.e., when 1.00 is not included in the confidence interval).

A concern was whether children drew the backgrounds or only the objects and whether they filled the picture space. Perhaps they remembered smaller-sized scenes as well as smaller-sized objects, a concern originally raised by Seamon (2002). Twenty-eight of the 29 children included the background in their drawings and 20 of those colored up to the edges of the drawing space. These findings suggested that children generally did follow instructions, and moreover that they remembered a more expansive background, consistent with BE.

As seen in Figure 2.2, the size of children's drawn main objects ($M=0.51$, $SD=0.35$), were reduced from the original basketball to a greater extent than adults ($M=0.80$, $SD=0.17$), $t(53)=2.82$, $p<.001$. Because children reduced the size of the main object to a greater extent than adults, one might assume that the children exhibited more BE. However, as previously described, in order to make such inferences, further analysis must be done to control for possible differences amongst developmental age groups. Perhaps the children simply draw smaller. Figure 2.3 contains samples of both groups' drawings from the Spontaneous Drawing task.

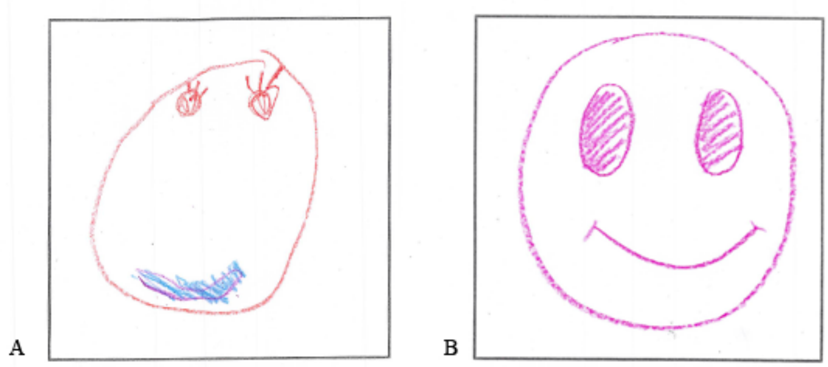


Figure 2.3: The spontaneous happy face drawings drawn by children (Panel A) and adults (Panel B). Drawings represent the mean from each group.

Children's (Figure 2.3 Panel A) and adults' (Figure 2.3 Panel B) spontaneous drawings were compared to each other in order to determine whether children spontaneously drew smaller-sized round objects than adults. Analysis of the drawings in Figures 2.1 and 2.3 indicated whether BE was exhibited through the memory drawing task, or whether children simply drew smaller-sized round objects. If both groups drew the big round object smaller in the memory task than in the spontaneous task, and included more background, then results suggest BE.

Children’s drawn happy faces (M=0.47, SD=0.23) were significantly smaller than adults’ (M=0.62, SD=0.17), t(53)=2.81, p=.007. As a result, children spontaneously drew smaller round objects than adults. Next I compared the results of the Spontaneous Drawing task to the results of the Memory Drawing task in order to determine whether one group exhibited more BE than the other. Figure 2.3 displays the mean proportion of both group’s object size in each task.

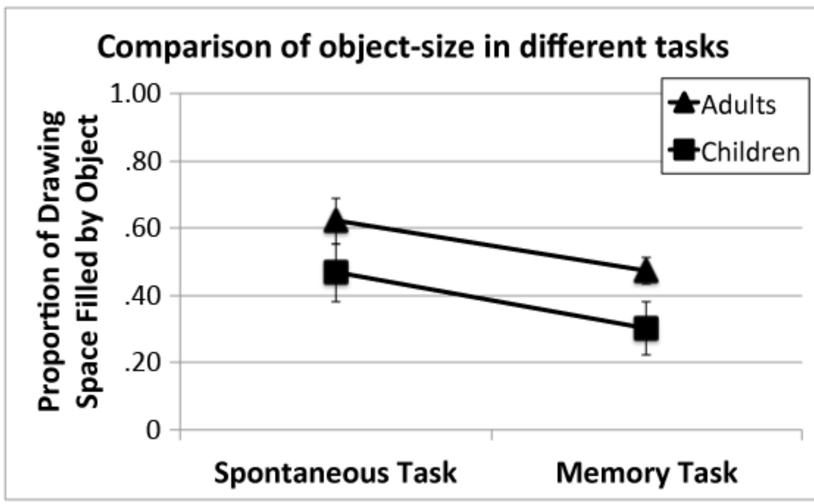


Figure 2.4: The mean proportion of drawing space each group’s main object occupied in both tasks. Error bars represent 95% confidence intervals.

Taken together, comparison of the drawn objects in the Memory and the Spontaneous Drawing tasks revealed whether participants always drew objects the same size, regardless of the task. A 2 (Subject Type: children or adults) X 2 (Task: spontaneous or memory) Mixed Measures ANOVA revealed a main effect of Subject Type, main objects in the adult’s drawings were larger than those in the children’s drawings, F(1,53)=501.69, p<.001 There was also an effect of Task, spontaneously drawn objects were larger than the objects in the Memory Task, $F(1,53)=30.90$, $p<.001$. Perhaps most importantly, there was no Subject Type X Task interaction, $F(1,53)=0.10$, NS. The lack of interaction, as also seen in Figure 2.4, suggests that they exhibited the same amount of BE because they reduced the size of the main objects in each task to the same extent.

When drawing a scene from memory, the children in this study included more of the background than adults, after only a number of seconds of viewing the photograph. However, results from the spontaneous task indicated that both groups were capable of drawing larger sized objects, but that children spontaneously drew smaller round main-objects than adults. Taken together, results from both tasks suggested that both groups experienced BE to the same extent.

Results revealed that four to five year old children, exhibited BE. In terms of dual representation (DeLoache, Miller & Rosengren, 1997), results also indicated that preschool-aged children and adults perceived the photograph of the basketball on the hardwood floor as part of a continuous world and not solely as a two-dimensional picture. However, converging evidence acquired through a task that did not require drawing was still needed.

Chapter 3

EXPERIMENT 2

The purpose of this experiment was to test BE without using a drawing task. A two alternative forced choice recognition task was designed, which allowed us to assess spatial memory for each picture within two seconds of viewing. This was useful for testing children because the simple matching task shortly (2 seconds) followed viewing a scene, and each participant was asked to simply indicate which of two scenes was identical to the original. Adults were tested using the same procedure to determine if these stimuli and test procedures would yield BE. Because the task involved a long stimulus duration and immediate test, there was concern that over the course of 40 trials, adults would develop a verbal strategy allowing them to select the correct picture at test. An example of a verbal strategy would entail memorizing the amount of space between the main object and the edge of the picture, instead of remembering the scene as a whole. If adults were at ceiling given the easiness of this task, there was a plan to run another group using the same task but briefer presentations.

The stimulus was either a close-up or wide-angle scene-view, and the choice pairs consisted of the same and the opposite image. If participants exhibited BE, then an error asymmetry should have been observed: more errors in which participants mistakenly selected the wider view than in which they mistakenly selected the closer view. Scene-pairs presented at test differed with respect to zoom-similarity (high and low) in order to see if similarity would impact the decision made by both children and adults. If participants found the low similarity too easy, then they might exhibit BE only when the scene pairs were more similar, being more likely to select the view that included slightly more of the surrounding background.

3.1 Method

3.1.1 Participants

Twenty-nine children (16 females) between the ages of 4 to 5 years (mean age=4.64, SD=0.36, range=4.14-5.30) from the University of Delaware's Early Learning Center participated in this study. Three children (two females) did not complete the task thus the data include the results from 26 children (mean age=4.65 years, SD=0.37, range=4.14-5.30 years). Twenty-six University of Delaware undergraduates (19 females) participating in the general-psychology subject pool (mean age=18.69, SD=0.93, range=18-21) took part as well. Twenty-six of the children, and all of the adults, who took part in Experiment 1 also took part in Experiment 2.

3.1.2 Stimuli

The stimuli were 40 photograph-scenes, each of a common object on a natural background. All images were printed on Hammermill Color Laser Gloss paper using an HP LaserJet office printer. Images were all 3"x 3". I expected 4-5 year-old children to easily recognize all scenes, which consisted of a main object in a realistic and likely location. Figure 3.2 shows one example of the Two-Alternative Forced Choice (two-alternative forced choice) options, which were displayed on a 3” by 6” paper with 2 images printed on it.

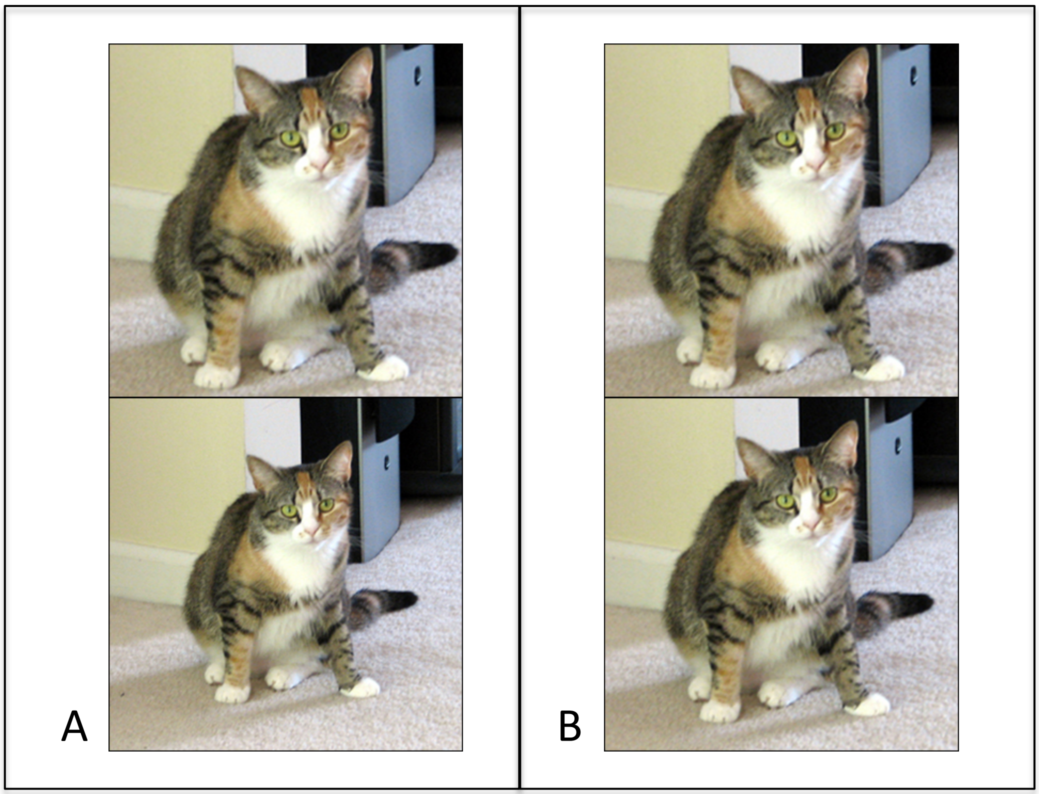


Figure 3.1: Stimulus-pairs used to test participant’s memory. An example of a low-similarity pair (Panel A) or high similarity pair (Panel B) were presented in the two-alternative forced choice recognition task.

Close and wide-angle pairs were either of high similarity (13% zoom) or low similarity (30% zoom) to each other. The close images were the same in both conditions, but the wide-angle image was what differed depending on the trial assigned to the participant (high or low similarity).

The forty photograph-scenes were presented to all participants in the same order. Similarity between the two-alternative forced choice options (high or low), location of correct answer (top or bottom), and location of close or wide scene (top or bottom), were presented equally often for each participant. For each scene these factors were counterbalanced across participants. All participants were randomly assigned to one of four conditions.

3.1.3 Design and Procedure

Children completed half of the 40 two-alternative forced choice trials on day one, and the other half on day two (between two to four days later). Each testing-session lasted approximately 30 minutes. Adults completed all 40 trials in one session, which lasted approximately 25 minutes. Each participant was tested individually, and the experimenter recorded all responses.

To ensure that children were able to differentiate between the close and wide versions of the same scene, there were practice trials set up in which they were first presented with a pair of images (a closer and wider view of the same scene) and were asked if they looked the same. The experimenter then presented another copy of one of the scenes, and the participant was asked to indicate which of the two it matched. Participants had to successfully respond to five out of six of these trials in order to pass criterion and progress to the two-alternative forced choice matching task. Two thirds of the child-participants were correct on all six trials, and one third missed only one trial. Not surprisingly, adults were correct on 100% of the trials.

The memory experiment consisted of 40 trials. On each trial, participants were shown a single picture (either close or wide) for 15 seconds. During this time they were asked to describe the main object and background and to try to remember the scene. The experimenter helped by encouraging participants, and by describing the main object's scene-context. The stimulus was immediately (approximately two seconds) flipped over and replaced with the test pair. Participants were asked to point to the image that was identical to the stimulus view, and received no feedback about their response.

3.2 Results & Discussion

In order to determine whether participants were exhibiting BE, I compared the proportion of errors made on close-up trials (when the stimulus was the closer view) to those made on wide-angle trial (when the stimulus was the wide-angle view). If BE occurred in memory, then more errors should be made on close-up trials because the participants would be more likely to mistakenly think they saw a more expansive background and erroneously select the wider view. However, if participants simply had poor memory for the scope of a view, then errors should not differ between close-up and wide-angle trials. Figure 3.2 shows the proportion of incorrect responses on close-up and wide-angle stimulus trials for the children and the adults on both high and low-similarity trials.

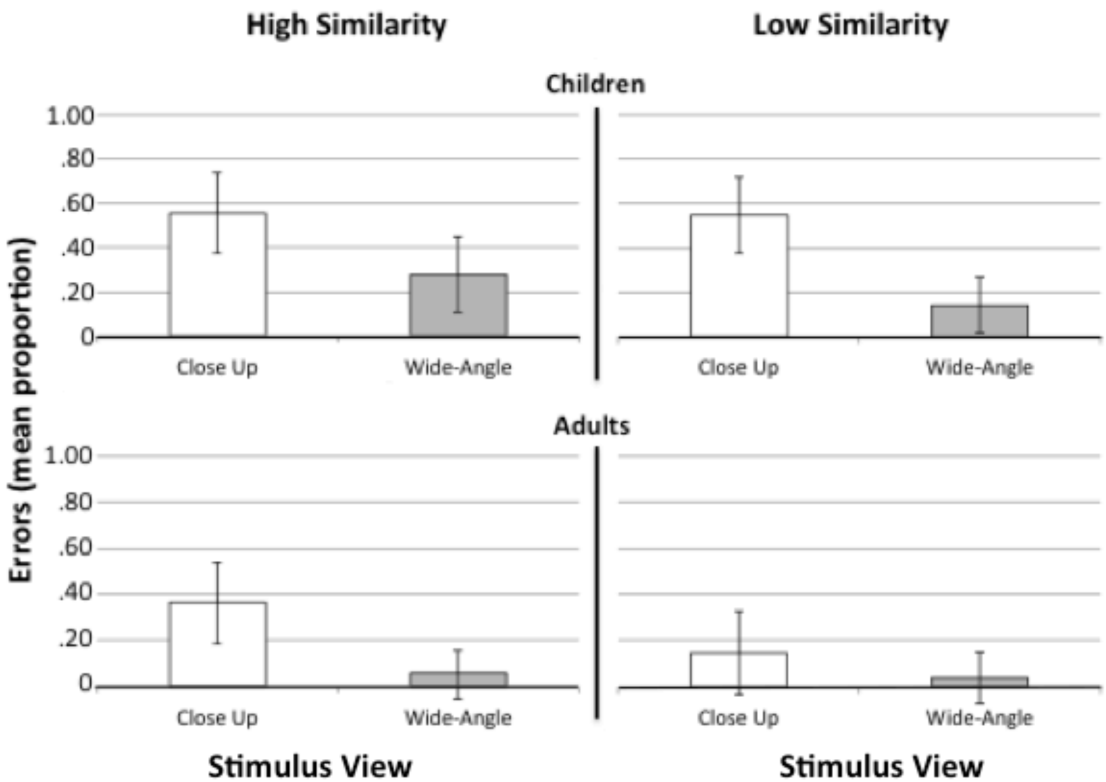


Figure 3.2: The mean proportion of trials on which there were errors, as a function of stimulus view and pair-similarity. Error bars represent 95% confidence intervals.

A 2 (Subject Type: adults vs. children) X 2 (Stimulus View: wide vs. close) X 2 (Similarity: high vs. low) Mixed Measure ANOVA showed that there was a main effect of Subject Type, children made more errors than adults, $F(1,50)=14.7$, $p<.001$. There was also a main effect of Stimulus View, the mean number of participants made a higher proportion of errors on close up, than wide-angle stimulus trials, indicating BE, $F(1,50)=62.86$, $p<.001$. Lastly, there was also a main effect of Similarity, participants made a higher proportion of errors when the image-pairs were highly similar, than when they were less similar, $F(1,50)=17.25$, $p<.001$.

The Subject Type X View interaction approached but did not reach significance, $F(1,50)=3.77$, $p=0.058$, and there was no Subject Type X Similarity interaction, $F(1,50)=1.09$, $p=0.30$. A significant 3-way interaction was obtained, $F(1,50)=18.16$, $p<.001$. Inspection of figure 3.2 suggests that this reflected a floor effect for adults (errors on wide trials were very rare).

In sum, in the time it took to replace the stimulus with the test pictures (2 sec), both children and adults erred more frequently on close trials than wide trials, indicating that BE had occurred. One question, however, was whether the same pattern of results necessarily reflected the same processes in both groups. In particular, one concern was that children might simply prefer the smaller pictures (wider views). The spontaneous drawing task showed that they drew smaller objects than did adults, and perhaps they preferred them. One argument against this was that like adults, children made more errors on high similarity pairs, indicating that they weren't simply selecting the wider view based on a preference. However, it is possible that great uncertainty on high similarity trials led them to guess more often, and their guessing was biased by a preference for the wider views. The possibility that children simply preferred the wider views was addressed in Experiment 3.

Based on the results in both Experiments 1 and 2, it appears that preschool-aged children, like adults, exhibited BE. Consequently, results have also indicated that their spatial thinking and dual representation are achieved similarly. Regardless, further analysis would confirm that the results of Experiment 2 in fact revealed BE and not a preference for wider-angle views. If this task was successful in determining the existence of BE, then it might be used to establish other aspects of spatial thinking as well as dual representation.

Chapter 4

EXPERIMENT 3

The purpose of this experiment was to determine if four to five year old children selected the wider-angle view more often due to a preference, rather than a memory error. Participants completed a Guessing Game task, which consisted of a similar two-alternative forced choice matching task, to the one used in Experiment 2. They simply guessed which of two visible scenes (a close-up or a wide angle view) was being hidden from view by the experimenter. No stimulus view was presented, and if children selected the wider view more often, then perhaps they have a preference for this view and did not exhibit BE in Experiment 2. However, if they revealed no preference or a preference or a preference for the close-up view, then they may have exhibited BE during the memory task.

4.1 Method

4.1.1 Participants

Twenty-six children (11 females) between the ages of 4 to 5 years from the University of Delaware's Early Learning Center participated in this study (M= 4.92 years, SD= 4.08, Range=4.07-5.74 years). Twenty (11 females) of the children (M=4.57, SD=0.38, range=4.14-5.30) from Experiment 2 participated in Experiment 3. Six (females) were lost through attrition (they were no longer enrolled at the center), and were replaced with six new children (males) (M=4.30 years, SD=4.07, Range 4.07-4.50 years).

4.1.2 Stimuli

Forty new scenes were created, and each designed to match the scenes from Experiment 2 in both category and in size of the main object. Stimuli were created the same way as in Experiment 2, with respect to similarity-pairs and printed using the same materials.

4.1.3 Design and Procedure

To ensure that children were able to differentiate between the close and wide versions of the same scene, the same criterion as in Experiment 2 was set. All participants met the criterion; twenty of the children were correct on all trials, and six missed only one trial.

The procedure was the same as in Experiment 2 except that instead of first presenting participants with a single scene to remember, they were instead presented with the two choices, and a confederate concealed the original scene from view. Participants were asked to select which scene they believed the experimenter was concealing.

4.2 Results & Discussion

Performance was evaluated by determining if children chose the close-up and wide-angle views equally often or if they had a preference for one view over the other. I compared the number of times they chose the close image to the number of times they chose the wide during a simple guessing game that had no right answer. If children had a preference for the wide-angle view, then perhaps they did not exhibit BE in Experiment 2. Instead, the results suggest that they had a preference for the wide-angle views in both experiments. Out of 100% of trials, I was interested in learning whether children always picked the wide-angle view more often. In particular, this experiment was designed to test if preschool-aged children would select the wide image as the correct choice equally often if let to their own devices. When guessing what the confederate sees, do the children choose the wider picture equally often (equal to 50%) or greater than chance (over 50%)?

I will report the data for this study in three ways. First, I will report the results for the set of 26 participants. Second, a separate analysis was done for the 20 children who participated in both Experiments 2 and 3, in order to determine whether specifically those who demonstrated BE previously, in fact revealed a preference for wide image views. Due to the fact that this study evaluated the spatial thinking of preschool-aged children, and the mean age of the full set in Experiments 1 & 2 (4.64) was a bit lower than that for Experiment 3 (4.92), I conducted a third analysis for the 20 participants who fell within this same age range as the previous experiments. This would reveal if any preferences were limited to this specific age range.

The full set of 26 participants selected the wide-angle view on a mean of 40% of the trials (SD=19%), which was significantly different from chance (50%), $t(25)=2.67$, $p=0.01$. They preferred selecting the closer views. To determine if similarity had any effect on the guessing pattern, I compared the mean number of times they selected the close up view on high-similarity trials (M=12.38, SD=3.53) to the number of times it was selected on low-similarity trials (M=11.54, SD=4.74), $t(25)=1.64$, $p=0.26$. Participants selected the close image equally often, regardless of similarity in scene pair.

Analysis of the 20 children who participated in Experiments 2 and 3 was also conducted in the same way. They selected the wide-angle view on a mean of 42% of trials (SD=16%), not significantly different from chance (50%), $t(19)-2.07$, $p=0.052$. They did not show a preference for the wider view, and selected the close and wide views equally often. In addition, there was no effect of similarity on guessing pattern because they selected the close-up view, the same number of times regardless of scene-pair similarity. They were just as likely to select the close-up view in high (M=12.05, SD=3.50) and low-similarity (M=11.0, SD=4.05) conditions, $t(19)=1.25$, $p=0.23$.

Finally, analysis of the 20 participants whose ages fell within the previous age group was also conducted in the same way. They selected the wider-angle view on only 40% (SD=21%) of the trials, which was significantly different from chance (50%), $t(19)=2.19$, $p=0.04$. They had a preference for selecting the close-up view of a scene. In addition, this group selected the close-up view the same number of times regardless of high (M=12.50, SD=3.94) or low-similarity (M=11.65, SD=5.26) conditions, indicating no effect of similarity, $t(19)=0.99$, $p=0.33$.

In sum, these results provide no support for the hypothesis that the children simply preferred the wider views. In fact, when a preference was observed the preschool-aged children preferred the closer views. Results support the conclusion that in Experiment 2, children's errors reflected BE in memory. Indeed, their bias toward selecting close-up views during a Guessing Game Experiment would mitigate against BE because they are not selecting a view based on preference.

Results revealed that the preschool-aged children in Experiment 2 exhibited BE similarly to adults. They demonstrated that both groups similarly achieved dual representation and spatial thinking. Importantly, the two-alternative forced choice matching task has been proven successful with these age groups and therefore may be successful in establishing these underlying cognitive abilities with other stimuli such as complex scenes.

Chapter 5

EXPERIMENT 4

Experiments 1-3, as well as prior BE research with children (Seamon et al., 2002; Candel et al., 2008) have tested spatial memory using single-object scenes. Adults are known to exhibit BE for more complex, multiple-object scenes (e.g., Gagnier & Intraub, 2013; Intraub & Richardson, 1989). The purpose of Experiment 4 was to determine if children too would remember complex scenes with extended boundaries or if the added complexity would be more taxing, leading simply to poor memory (equal errors on close and wider-angle trials). There is evidence that young children may have a lower working memory capacity than adults on a variety of memory tasks (Cowan, Hismajatullina, AuBuchon, Saults, Horton & Towse, 2010), and complex scenes may require holding more objects in working memory. Although during natural viewing we sometimes look closely at a single object, most views of the world include many objects. Thus it is important to determine whether BE in children is limited to simple scenes or whether it is evident in memory for more complex naturalistic views of the world.

5.1 Method

5.1.1 Participants

Thirty-five children (21 females) between the ages of 4 to 5 years from the University of Delaware's Early Learning Center participated in this study. None of these had participated in any of the previous experiments. Eight children (four females) did not complete the task thus the data include the results from 26 children (M=4.36 years, SD=0.30, Range=4.01-5.02). Twenty-six University of Delaware undergraduates (12 females) participating in the general-psychology subject pool (M=18.62 years, SD=18.62, Range=18-25 years) took part as well.

5.1.2 Stimuli

Forty new scenes were created, featuring multiple objects. Since these complex scenes were not focused tightly on one single object, they were generally wider-angle than the single-object scenes in the previous experiments. Figure 5.1 shows an example of high- and low-similarity pairs of complex scenes, made in the same way as those in Experiments 2 and 3.

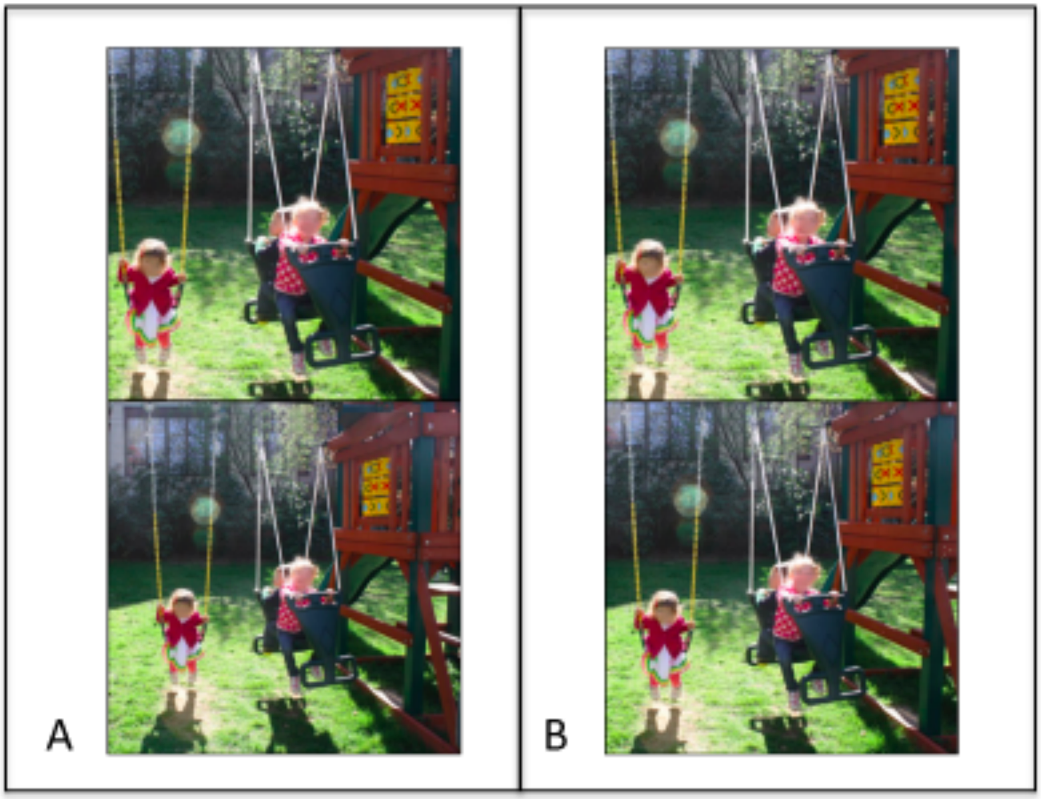


Figure 5.1: Stimulus pairs used to test participant's memory. An example of a low similarity pair (Panel A) or high similarity pair (Panel B) were presented in two-alternative forced choice.

5.1.3 Design and Procedure

To ensure that children were able to differentiate between close and wide versions of the same scene, the same a priori criterion as in Experiments 2 and 3 was set. All participants met the criterion; 14 out of 26 children were correct on all trials, and 10 missed only one trial. As expected, adults were correct on 100% of the trials.

Participants followed the same procedure used in Experiment 2, in which they were first presented with a scene for 15 s and subsequently given a two-alternative forced choice recognition test consisting of the same scene and a closer-up or wider-angle alternative.

A short guessing-game (similar to that in Experiment 3) was added to the end of the children's trials in order to examine whether they had a preference for selecting close up or wide-angle views of multi-object scenes. Children completed six trials (identical to those in Experiment 3) with new, complex scenes. Twenty-five children completed these trials and were included in the final analysis. One child's data had to be removed due to her anxiety with the possibility of being incorrect, and her playing according to modified instructions.

5.2 Results & Discussion

Data were analyzed in the same way as in Experiment 2, and Figure 5.2 shows the proportion of incorrect responses on close-up and wide-angle stimulus trials for children and adults.

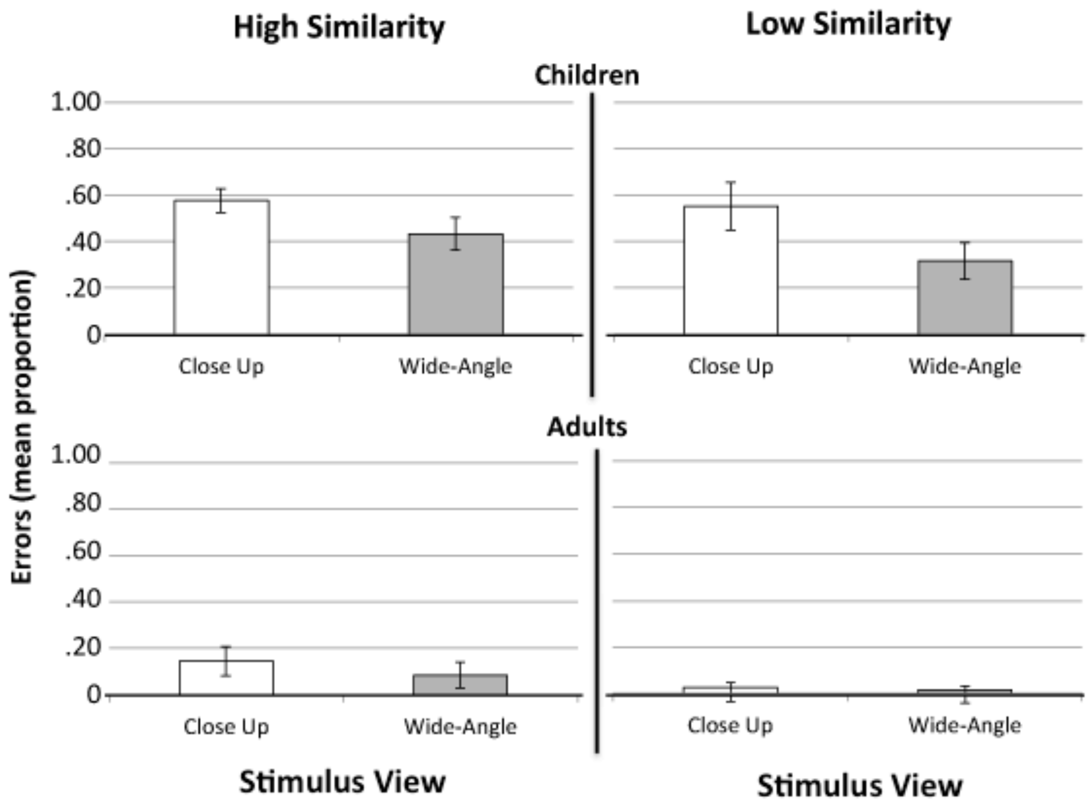


Figure 5.2: The mean proportion of errors as a function of stimulus view and similarity. Error bars represent 95% confidence intervals. As shown by the confidence intervals, adults made a significant number of errors only on high-similarity trials.

The Subject Type X View interaction indicated that the pattern of errors, BE, was driven by the children's errors, $F(1,50)=6.36$, $p=0.01$. There was no Subject Type X Similarity interaction, $F(1,50)=0.38$, $p=0.54$, and no Stimulus View X Similarity interaction, $F(1,50)=0.59$, $p=0.30$.

Although results were significant, analysis was done with the children's data to establish whether their pattern indicated BE. Overall, children made more errors on close-up stimulus trials (56%) than on wide-angle stimulus trials (36%), $t(25)=4.74$, $p<.001$.

As mentioned previously, the children completed a Guessing Game task. Their performance was evaluated by determining if the mean proportion of times those children selected the wide-angle view differed from chance. They selected the wide-angle view on 35% (SD= 25%) of the trials, which was significantly below chance (50%), $t(25)=976,.57$, $p<.001$. This indicated that as in Experiment 3, they selected the close-up view more often. They also showed no preference between selecting the wider angle view when the scene similarity was high (13%) or low (30%), $t(25)=.35$, $p=0.73$.

Children exhibited BE when viewing complex scenes. Again, the alternative hypothesis that results reflected a bias for wide-angle views was ruled out because the children demonstrated a preference for close-up scene-views. As was true with the simple (single-object scenes), children preferred selecting the close-up view during the Guessing Game, indicating that they in fact exhibited BE during the two-alternative forced choice recognition task. The matching task was clearly too easy for adults, and they might have developed a verbal strategy for selecting the previously viewed scene, perhaps mentally measuring and remembering the amount of space between the objects and the borders. Would increasing the difficulty of the task reduce the likelihood that adults develop such a strategy when trying to remember complex scenes?

Chapter 6

EXPERIMENT 5

The purpose of Experiment 5 was to reduce presentation time to determine whether the complex stimuli used in Experiment 4, would elicit BE in adults. As stated in Chapter 3, there was concern that 15 s stimulus durations might be so long for adults that the test (given 2 s later) would be trivial, and a floor effect would occur. This was not the case with the tight close-ups used in Experiment 2, but clearly in Experiment 4, with wider-angle views, adults were highly accurate in selecting the correct test picture. Wide-angle views have been previously found to yield less BE in adults (e.g. Intraub & Richardson, 1989; Intraub, Bender & Mangels, 1992; Intraub et al. 1996). Thus, the stimulus duration was reduced to 5 s and focused particularly on the high similarity pairs, to determine if the wider-angle views would yield BE using the same basic task as the children in Experiment 4.

A second purpose of this experiment was to introduce a Guessing Game Task for adults. Although one might assume that adults would not have a bias for close-up or wide-angle scenes, this has never been tested. Because some children have exhibited a preference for close-up views (Experiments 3 and 4), a clear test might eliminate the possibility that adults have a preference for wide-angle views as well.

6.1 Method

6.1.1 Participants

Twenty-six University of Delaware undergraduates (16 females) between the ages of 18-23 (M=18.75 years, SD= 1.13, range: 18-23) participating in the general-psychology subject pool took part in this experiment.

6.1.2 Stimuli

The same 40 (multi-object) scenes used in Experiment 4, were used in the two-alternative forced choice recognition task. Another 12 (multi-object scenes) were used for the Guessing Game task.

6.1.3 Design and Procedure

One experimenter administered the tasks to two participants at a time. They first completed the short Guessing Game task (12 trials) and were then given the two-alternative forced choice recognition task. For the Guessing Game task, only one experimenter was present, so concealed the stimulus view and simultaneously presented the two-alternative forced choice pair. Participants were asked to provide their responses (which scene they believed was concealed) on their own response sheets. For the two-alternative forced choice recognition task, participants followed the same procedure used in Experiments 2 and 4, in which they were first presented with a scene and subsequently given a two-alternative forced choice recognition test consisting of the same scene and a closer-up or wider-angle alternative. In this experiment the scene they had to remember was only presented for 5 s, and participants also recorded their own responses.

6.2 Results & Discussion

As in Experiments 2, 3 and 4, the close and wide scene pairs in the high-similarity trials were by nature more difficult to distinguish. As a result, all participants in experiments 2 and 4 made more errors on high than on low-similarity trials. Because adults' performance was at ceiling in Experiment 4, the following analysis started by comparing the number of close and wide errors adults made after viewing complex scenes when the similarity was high. Figure 6.1 shows the results for the proportion of incorrect responses that adults made on close up and wide-angle stimulus trials for high and low-similarity conditions. If adults exhibited BE for these complex scenes after viewing them for five seconds, then this pattern of errors would be most visible on High Similarity Trials. However, there was also the possibility that BE would be visible in the Low Similarity Trials.

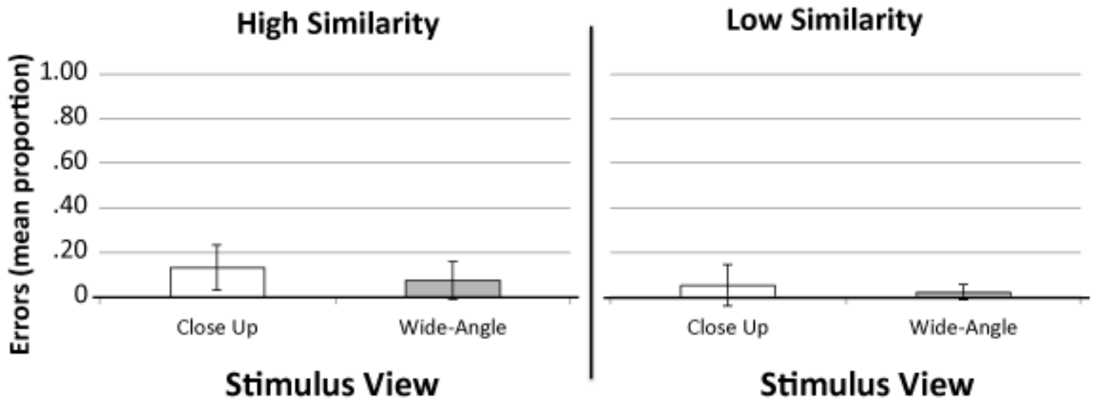


Figure 6.1: The mean proportion of errors made by adult participants as a function of stimulus view and similarity. Error bars represent 95% confidence intervals. As shown by the confidence intervals, they made a significant number of errors only on high-similarity trials.

Results were analyzed differently from Experiments 2 and 4 because I was not sure if I could reduce the speed of presentation enough for participants to exhibit BE. In particular, I was interested in the high-similarity trials and therefore only wanted to look at those to see if in each of those instances adults made more errors on close-up than wide-angle stimulus trials. On the High Similarity trials, participants made more errors on close-up stimulus trials (13.10%) than on wide-angle stimulus trials (7%), $t(25)=2.12$, $p<0.05$. However, on Low Similarity trials there was no statistically significant difference between making errors on close-up stimulus trials (5%) than wide-angle stimulus trials (2%), $t(25)=1.25$, $p=0.22$ not exhibiting BE.

Performance on the Guessing Game task was evaluated by comparing the number of times participants selected the wide-angle view to chance. Adults selected the wide-angle view on 47% (SD=16%) of the trials, and they were not significantly different from chance, t(25)=0.84, p=0.41. In addition, this lack of preference was consistent regardless of scene-pair similarity. There was no difference between selecting the wide angle view when the scene similarity was high (M=3.04, SD=1.59) or low (M=2.65, SD=0.89), t(25)=1.11, p=0.28. Adults were just as likely to select the wide-angle view regardless of scene-pair similarity.

In sum, adults exhibited BE during shorter presentation times when they were unable to develop a strategy and the similarity between the images was high. Upon analyzing the high-similarity trials, there was evidence that these stimuli do elicit BE in adults. In addition, adults were found to have had no preference for either close-up or wide-angle views of scenes, indicating that they did in fact select the wider-view more often during the recognition task because they exhibited BE.

Chapter 7

CONCLUSION

The aim of this study was to determine if preschool-aged children (4-5 year olds) exhibit BE and to develop a new method that would allow assessment of BE without having to rely on drawings. These were accomplished by using a drawing task along with a control, and developing a simple matching task that could be used to determine which of two scenes (the same or a closer versus wider-angle view) participants remembered. Children as young as four to five-years of age were found to exhibit BE in memory for simple (single-object: Experiments 1 & 2) and complex (multi-object: Experiment 4) scenes. Both a drawing and a two-alternative forced choice recognition task showed that children this age exhibited a spatial memory error similar to adults, remembering a more expansive view than the one they saw. This suggests that these same underlying cognitive processes that are evident in adulthood are present early in development. It also shows that a recognition test can be used to explore young children's spatial memory for scenes, and raises opportunities for studying other cognitive processes related to scene representation. First I will discuss each experiment in turn. Then, I will discuss how the findings relate to the Multisource Model (Intraub, 2012), to the issue of dual representation, and lastly I will propose future research that can develop from the present findings.

The drawing task (Experiment 1) tested the youngest children to date (four to five-year olds) with an explicit memory task and found that they exhibited BE within seconds of having seen a close-up photograph; in this case a picture of a basketball on a wooden floor (Figure 2.1). Children and adults drew a smaller basketball than the one in the photograph, and more of the surrounding space. Results replicated findings by Seamon et al. (2002) in which children (six years of age) drew a smaller object, and included more of the background than was present in a photograph, compared to college-aged adults. Seamon et al. (2002) suggested that this reflected a greater tendency in children to make a source monitoring error and thus attribute more extrapolated space to have been seen. However, the spontaneous drawing task conducted in Experiment 1 showed that in the absence of a memory test, these young children, when drawing a "great big happy face" drew smaller faces that did the adults. Results suggested that children spontaneously drew smaller-sized round objects, and that drawing tendencies should be taken into account when comparing memory of object sizes across developmental stages.

Does this mean that children did not exhibit BE, or that they just drew smaller objects? A comparison of the drawings in both tasks suggests that BE nonetheless occurred. By comparing the sizes of the objects in both tasks, I found that both groups reduced the sizes of the main objects by the same amount. Thus, it appears that like adults, the children experienced BE. The lack of interaction between the children's and adult's drawings in each task provides no support for the idea that preschool children are prone to more BE than are adults. The outcome also underscores the importance of obtaining evidence for BE using a task that does not involve drawings (the two-alternative forced choice matching task). The concern that children might not be able to complete the task because they were too young to draw good representations (e.g., tadpole-like representations of people) was not borne out. No tadpole drawings were observed, and children's drawings from memory were rather good. Regardless, it is critical to provide converging evidence for children's BE without a drawing task.

A two-alternative forced-choice recognition task (Experiment 2) was designed to provide converging evidence for BE without requiring any drawings to be made. A criterion was set prior to participation in order to establish whether children could differentiate between simultaneously presented close and wide pairs. Children were successful in distinguishing between the views in both the high and low similarity conditions, clearly distinguishing that there was a difference between the views. Seeing that the close and wide pairs could be differentiated, the current study set out to establish and was successful in finding that children would be prone to mistaking the wider view after studying the closer view.

In the recognition memory task (Experiment 2), participants viewed a scene for 15 seconds trying to remember it to the best of their ability. Approximately two seconds later, the stimulus was replaced with the test card containing the same view and a closer or wider pair. Participants then indicated which of the two pictures on the test card most closely resembled the stimulus image. On close-up stimulus trials, both children and adults chose the wider-angle scene more often, claiming it was the one they had just seen. On wide-angle trials, both children and adults were more accurate, and were less likely to select the close-up scene as being the one that they had just viewed. This indicates that both groups of participants exhibited BE because they made more errors on close-up stimulus trials, in relation to wide-angle stimulus trials. Instead of making bi-directional errors, the more common mistake involved remembering a more expansive view than was originally present. Adults also exhibited BE in both the high similarity and low similarity conditions, although the number of errors was much smaller than was the case for the children.

An alternative explanation of the results is that children may have selected the wider-angle view, not because of BE, but because they simply preferred the smaller object. Findings from Experiment 1 indicated that this age group generally drew smaller-sized objects; perhaps they also preferred pictures with smaller objects. In Experiment 3, the Guessing Game task, children were asked to simply select which of two scenes was being concealed from view. Results showed that children selected the closer view more often, suggesting that if anything, their memory errors (in Experiment 2) underestimated BE because they showed an overall bias to select the closer view regardless of the task they are given. Experiments 1 through 3 demonstrated that four to five-year old children and adults achieved dual representation and exhibited BE similarly.

Experiment 4 was designed to test whether children would exhibit BE for complex (multi-object) scenes. In Experiment 4, the two-alternative forced choice recognition task was redone with complex scenes. Results indicated that children exhibited BE for multi-object scenes, mistakenly selecting the wider view more often than the closer view. The same spatial memory error that children exhibited with simple scenes also occurred with scenes containing more than one object. Consequently, I wanted to test whether adults would similarly exhibit BE and therefore achieve dual representation, with the same complex stimuli and recognition task.

With the complex scenes, which happen to also be more wide-angled than the simple scenes, adults rarely made errors and consequently did not exhibit BE in this task (Experiment 4). Previous studies have established that wider-angle views elicit less BE in adults (Intraub & Richardson, 1989; Intraub, Bender & Mangels, 1992; Intraub et al. 1996) and that views showing less background surface lead to greater BE (Gagnier, Intraub, Oliva, & Wolfe, 2011). In addition, adults have been found to exhibit BE with complex scenes (Gagnier & Intraub, 2013). In the present study, the more complex views were by nature wider-angle, capturing more of the scene than the tight close-up views in Experiment 2. This would make the discrimination relatively easy at test. In Experiment 5, stimulus duration was reduced to five seconds, and upon analysis of the high-similarity trials, adults made more errors on close-up stimulus trials, exhibiting BE. This showed that the complex stimuli did elicit BE in adults when stimulus duration was reduced because they were unable to develop a verbal strategy, and relied exclusively on scene-memory. Children and adults mistakenly selected the wide-angle view more often, remembering more surrounding space for the same complex scenes.

As previously explained, the observation of BE in preschool-aged children also addresses important issues about dual representation and spatial thinking. Dual representation (Deloache et al., 1997) is the ability to understand a given picture of a scene as both a discrete symbol and as a representation of real space. When someone exhibits BE after viewing a photograph, they do so because they interpreted the given scene as pertaining to a continuous world and not as a paper with symbols. Because the preschool-aged children in the current study exhibited BE they, like adults, most likely interpreted these pictures as two-dimensional photographs and as real-world scenes. Upon viewing both simple and complex scene-photographs, four to five-year old children and adults did not solely represent these pictures as pieces of paper with colors and shapes on them. Both groups in our sample appear to have similar scene representations; they both exhibited the same error that involved remembering visual stimuli just beyond the borders of a view.

Questions have been raised regarding children's ability to represent pictures as scenes (Liben, 2003) as well as their ability to form symbolic relations between small and large versions of the same three-dimensional space (Deloache et al.,1997). I infer that the four to five year old children tested here represented the pictures as scenes, because after viewing them they exhibited BE. In terms of the Multisource Model (Intraub, 2012) results suggested that children, like adults, viewed a picture, but amodal perception, layout extrapolation, and world knowledge generated a scene representation. Indeed amodal perception has been shown to occur even in infancy (Kellman & Spelke, 1983). Subsequently in memory, children like adults, misattributed some of the non-visual scene representation to having been seen, experiencing BE.

According to the Multisource Model (Intraub, 2012) BE is a source monitoring error in which observers misattribute imagined parts of a scene (based on amodal perception and world knowledge) to visual memory. However, the question of whether BE can be influenced in the same way as other source monitoring errors, is something that could be further addressed. Crawley, Newcombe & Bingman, (2010) demonstrated that when children watched a video and attended to certain non-perceptual features of the source (e.g., emotion of the speaker or listener) they were less likely to commit a source monitoring error than if they focused on perceptual features (e.g., sound quality). The two-alternative forced-choice matching task (used in Experiments 2, 4 and 5 of the current study) could be modified to test whether asking children to focus on such a feature (e.g., the emotion of the person or animal compared to the image-quality of the photograph), leads to more errors. If participants mistakenly select the wider-angle view more often than the close-up view when attending to the emotion, then there may be evidence to suggest that BE can be affected in the same way as other source monitoring errors. They would be more susceptible to errors when focusing on emotional compared to perceptual details of the elements in the scene. This might provide additional evidence for the second stage of the Multisource Model (Intraub, 2012).

The two-alternative forced choice recognition task developed for the present study can also be used to test other aspects of children's spatial cognition. Do four to five-year old children exhibit BE for imagined scenes? Intraub et al. (1998) found that adult's memory of outline-objects differed when they imagined a background. Conducting the same task with preschool-aged children may be too complex, but use of the novel recognition task used in Experiments 2 and 4, can test whether four to five-year old children exhibit BE for imagined scenes. For example, the scenes used here can be replaced with outline objects similar to those used by Intraub et al. (1998) in Figure 1.2. Instructions can consist of asking children to remember the size of the object, or asking them to remember the size but to also imagine a background for the object. If children exhibit BE for imagined scenes, similarly to adults, they may mistakenly select a smaller-sized object than the one they saw, remembering a more expansive imagined scene. As a result, there may be further evidence for similarities in underlying cognitive processes involved in spatial representation, early in development. However, if children do not exhibit BE for imagined scenes, they may not be recruiting the same processes as during scene perception, but rather later in development.

The present study has been successful in demonstrating that preschool-aged children and adults exhibited a scene memory error after viewing two-dimensional scene-photographs. However, it has not yet been established whether children exhibit this constructive memory error after viewing or feeling (through touch), three-dimensional scenes. Intraub (2004) found that adults experienced this memory error in both of these instances, indicating that this phenomenon is not limited to people remembering more of the background in pictures. Future research may investigate whether children, similarly to adults, exhibit BE through these other modalities. If children's BE is limited to two-dimensional pictures, then the underlying processes involved in spatial representation at this stage in development may not extend to three-dimensional space. Perhaps smaller objects (such as those that may be used in a dollhouse (i.e. miniature furniture) could be arranged on table-top surfaces to resemble scenes. Children could be blindfolded and instructed to either explore the scenes through haptic touch, or view them from afar. By later asking them to manually place the scene's borders where they belong, one could see if children remember more surface area than was originally present, similarly to adults.

In conclusion, the present study was successful in accomplishing both of its aims. I not only established that a younger group than ever before tested through explicit means, exhibits BE similarly to adults, but provided a new paradigm that is simple enough to test four to five-year old children's scene-memory. Preschool-aged children and adults did the same thing (remembering a wider, more expansive scene) and the novel matching task can be used to test this. In addition, prior issues with methodology involved in testing children's BE (Seamon et al., 2002) were also addressed. The children tested exhibited a spatial representation similar to adults, and were prone to the same non-visual errors following presentation of a scene-photograph. In addition, evidence that they achieve dual representation has also been established. Further studies can use the new two-alternative forced-choice task in order to understand more about children's, and subsequently, adult's spatial thinking. Lastly, this task can be manipulated to further test other stages of processing related to our spatial representation, such as source monitoring and imagery. The work presented here lays a solid ground to build off of in future studies on children's spatial thinking.

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Appendix A

IRB APPROVAL LETTER—ONE

Please note that University of Delaware IRB has published the following Board Document on IRBNet:

Project Title: [272447-1] Spatial Cognition in Children Principal Investigator: Helene Intraub

Submission Type: New Project
Date Submitted: September 19, 2011

Document Type: Approval Letter
Document Description: Approval Letter
Publish Date: September 21, 2011

Should you have any questions you may contact Jody-Lynn Berg at jlberg@udel.edu.

Thank you,
The IRBNet Support Team

www.irbnet.org

Appendix B

IRB APPROVAL LETTER –TWO

Please note that University of Delaware IRB has published the following Board Document on IRBNet:

Project Title: [272447-2] Spatial Cognition in Children Principal Investigator: Helene Intraub

Submission Type: Continuing Review/Progress Report Date Submitted: September 20, 2012

Document Type: Approval Letter
Document Description: Approval Letter
Publish Date: September 20, 2012

Should you have any questions you may contact Jody-Lynn Berg at jlberg@udel.edu.

Thank you,
The IRBNet Support Team

www.irbnet.org

Appendix C

IRB APPROVAL LETTER –THREE

Please note that University of Delaware IRB has published the following Board Document on IRBNet:

Project Title: [157572-2] Spatial Cognition Principal Investigator: Helene Intraub, PHD

Submission Type: Continuing Review/Progress Report Date Submitted: January 13, 2011

Document Type: Approval Letter
Document Description: Approval Letter
Publish Date: January 14, 2011

Should you have any questions you may contact Jody-Lynn Berg at jlberg@udel.edu.

Thank you,
The IRBNet Support Team

www.irbnet.org

Appendix D

IRB APPROVAL LETTER –FOUR

Please note that University of Delaware IRB has published the following Board Document on IRBNet:

Project Title: [157572-5] Spatial Cognition Principal Investigator: Helene Intraub, PHD

Submission Type: Continuing Review/Progress Report Date Submitted: February 8, 2012

Document Type: Approval Letter
Document Description: Approval Letter
Publish Date: February 8, 2012

Should you have any questions you may contact Jody-Lynn Berg at jlberg@udel.edu.

Thank you,
The IRBNet Support Team

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