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(The pilot of a new adapted A-not-B interactive online task)

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Abstract

One of the recent issues in cognitive sciences is investigating the influence of the social setting on cognitive abilities rather than studying the solitary mind. Recent studies have shown the influence of social agent in memory modulation, especially in infancy. The current study investigated whether infants remember the new location of an object better if they witness the location change with the social agent. To this aim, the well-known A-not-B task was used. In this task, infants are asked to retrieve the hidden object after a short delay which they usually do correctly. After several retrievals of the object from the same location (location A), infants continue to search for it there even they see it was hidden at the new location (location B). Previous studies concluded that the delay between hiding and retrieving might interfere retroactively with the latest location memory, or the repeated successful retrieval from the first location might interfere proactively with the memory of the new location. As of our hypothesis, we performed the A-not-B task in two different social (co-witnessing the location change) and nonsocial (witnessing alone) conditions. We didn't find a significant difference between conditions due to the ceiling effect caused by the subject's age.

Keywords: A-not-B task, perseveration error, object-permanence, memory, social effect, altercentrism

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Introduction

Representation of the surrounding environment is one of the fundamental issues in cognitive psychology, as it constitutes our representation of the physical world (Káldy & Sigala, 2004). Notably these mental representations of the nearby setting are not the most accurate representation of the actual physical world. In fact, human perception is susceptible to be biased from different factors, especially the social setting (Kampis et al., 2021). Humans have much more complicated cognitive and social abilities than other species. These two abilities seem to be linked, which means that advanced cognitive abilities cannot develop without communication skills; complicated social communication like verbal interactions which cannot occur without enough cognitive capacities. To bridge the gap between cognitive and social science dimentions, one should notice that social setting is not a simple temporal-special coincidence of two persons. Moreover, there is a dynamic process in a social setting that causes coordination and participatory sensemaking (De Jaegher & Di Paolo, 2008).

Social Influence

Recent experiments have revealed that our cognitive abilities change profoundly in social situations. This phenomenon is called altercentrism, which means "the sensitivity to others and the targets and content of their attention," which influences human actions, perception, judgment, and memory (Kampis & Southgate, 2020). This social modulation does not necessarily happen in interactive situations. It influences all cognitive domains in the presence of an agent even when their presence seems entirely irrelevant for the performing task. Among all social effects, shared gaze has been studied extensively. Various studies with different measurements recognition, localization, and discrimination of objects have shown that valid gaze-cuing enhances the response accuracy and decreases the reaction time. For instance, it has been shown that joint attention empowers recalling the memorized words even when memorizing isn’t explicitly aimed. In contrast, other nonsocial types of cueing don’t. Also, the working memory works efficiently in the valid gaze cuing compared to invalid conditions and increases the processing speed (Gregory & Jackson, 2019).

The effect of a social agent in structuring memory has also been observed in developmental psychology. A study with 9-months-old infants has shown that the novelty preference of infants who saw a human agent perform an activity was much higher than those who saw a claw do the same action (Howard & Woodward, 2019). Presumably, it has an evolutionary advantage. Human infants need to learn a lot; despite not having enough abilities to act by themselves in the environment, they have to rely on others' and target of their perception due to limited and undeveloped cognitive, sensorimotor skills. Some claim that such ability to learn quickly from social circumstances is an essential capability of human infants. This kind of interpretation has also been used to explain the inconsistency between the implicit and explicit theory of mind results (Kampis & Southgate, 2020).

Implicit and Explicit theory of mind

Theory of Mind (ToM) is an essential concept in any social situation. ToM is the ability to represent others' mental states and consider their knowledge, beliefs, and desires. It also highlights that in case of inconsistency between people's beliefs and reality, people would act according to their beliefs (Frith & Frith, 2005). Consequently, inferring mental states to others causes their unmatching behavior with reality to make sense. This ability to understand others' false beliefs is the central part of ToM tasks (Wimmer & Perner, 1983). Failure to pass the classic ToM tasks indicates that children below four years lack this ability.

In one of the famous tasks, Sara puts a marble in a basket, and then she leaves the room; Anna comes and transfers the marble from the basket to a nearby box. Children are asked, "Where will Sara search for a marble?" studies have shown that children below four years old answer wrongly to this question. This had been concluded as a lack of ToM abilities below this age.

Further studies by using new methods questioned this conclusion. The Violation-of-Expectation (VoE) and the Habituation-Novelty (HN) techniques are often used to explore the infant's understanding of the surrounding environment (Dunn & Bremner, 2017). Infants are exposed to a stimulus or class of stimuli until the time of looking decreases and the infants become accustomed to it. Then, a test trial measures infants' preference for stimuli in the same category or novel stimuli. Prolonged looking is considered as an index of discrimination between two stimuli, but not reasoning about events (Slater & Morison, 1985; Wang et al., 2004). Children see a familiarization event in violation of expectation tasks, like habituation novelty. But later in test trials, two outcomes occur, possible and impossible. The impossible event is expected to capture the infant's attention and lead to prolonged looking (Renée Baillargeon, 1993).

Standard ToM tasks, like Sara's marble, mainly rely on language and reasoning abilities (Wiesmann et al., 2020). While in looking measurements, an infant should predict the behavior of an agent who holds false beliefs about the object's location. In a VoE study by Onishi and Baillargeon (Oniski & Baillargeon, 2005), which was performed using videos it has been suggested that 15 months old infants can attribute false belief to an agent. There were two boxes, yellow and green, and a toy standing between them in their study. A female agent enters, holds the toy, plays briefly, and then puts it inside the green box. While her hand was in the box, the video paused, and the first trial ended. In the second trial, there were just boxes, and in the third one, the agent came and reached inside the green box, and while her hand was inside, it was paused. After this familiarization trial, there were two belief induction trials. The toy was moved to a yellow box after the agent left the scene (false-belief-green condition). In the false-belief-yellow condition, the toy was moved to the yellow box, but in the agent's presence, then after the agent left, it was returned to the green box. Finally, the agent reached either the green or yellow box in the test trials. As mentioned before in the VoE technique, an extended look at an event that violates their expectations is awaited. Interestingly, the infants looked reliably longer when the agent didn't reach where she falsely believed the toy was (Renée Baillargeon et al., 2010).

The difference between these implicit ToM tasks and the traditional explicit ones has been a controversial issue. If infants pose the ability to attribute false belief to others from early infancy, measured in implicit tasks, there should be an explanation for their later failure in explicit ones. There are two different viewpoints for explaining this discrepancy between the implicit and explicit theory of mind tasks findings.

Substantial-Continuity view

A group of researchers believe in a conceptual or substantial-continuity view, which means that the ability measured by implicit and explicit ToM tasks is the same (Povinelli & Preuss, 1995). In this view, false belief understanding emerges early in life and becomes sufficient and complex with experience during the development. Their explanation for the failure in traditional ToM before the age of 4, inconsistent with posing this ability from early infancy, is that in standard ToM tasks, unlike spontaneous tasks, three different processes are needed: 1- false-belief representation 2- answer-selection process 3-response-inhibition process. When asking, "where will the agent search for the object?" children have to represent an agent's false belief and inhibit their knowledge about the correct location. These processes are high-demanding cognitive abilities that involve a different area of the brain. The immature and not fully connected brain prevents toddlers from passing these tasks. Take, for example, the temporoparietal junction activates in mind reading tasks. The anterior cingulate and prefrontal cortex are usually involved in response selection. For that reason, the connection between frontal and temporal lobes is needed to pass the explicit tasks. In this theory, as to pass the implicit ToM, just the false belief representation process is involved, infants could pass these tasks (Renée Baillargeon et al., 2010).

Fundamental-Change view

In the second point of view, the fundamental-change view, it is believed that it is not the preliminary ToM that causes the successful performance of children below four years old. It is believed that these tasks measure two different processes with different developmental trajectories. One evidence for this view is the Association between passing traditional ToM and the brain structure in the core ToM region. Children around four years can pass explicit ToM because the related brain area has developed enough. An MRI study by Grosse Wiesmann questioned the explanation for unsuccessful implicit ToM until age four. This study didn't show an association between the brain area involved in language or executive function and succession in these tasks. Additionally, they found an association between successful implicit ToM and other brain regions rather than the ones involved in explicit (Grosse Wiesmann et al., 2017).

Also, the explanation from the substantial-continuity view for the successful performance at implicit tasks doesn't seem plausible. The description of how infants can pass implicit tasks but not the explicit ones, attributing two different representations, doesn't seem plausible due to their limited and undeveloped cognitive abilities. Having two different representations from the object's location (the actual location of an object and its location from the agent's perspective) is highly demanding. During the anticipatory looking or VoE experiments, infants must access both representations. When the agent comes back to the scene, they should inhibit their representation from the actual location in favor of the agent's mental state to have a correct-looking behavior—considering infants' immature cognition cast doubts on this explanation.

The evidence mentioned above, especially recent brain imaging and longitudinal studies, cast doubt on the conceptual-continuity view. Among fundamental-change views, altercentrism theory has relied on social influence to explain the discrepancy between the implicit and explicit theory of mind tasks.

In the recent theory, it has been suggested that infants are altercentric. When a salient agent interacts with a child or acts on the object, children have only one, the same as the agent, instead of having two different representations. Children pass implicit ToM because they believe that the object is there. To put it differently, in the same situation, events encoded with a social agent are much stronger than those witnessed lonely. In the famous ToM scenario, children always encode an event with a social agent. To induce a false belief, they have to witness some changes in objects' location alone or with another agent, which do not have a representation as strong as the first one. Therefore, while assessing Violation of Expectation (VoE) or Anticipatory Looking (AL), children have a salient memory for the events encoded with the agent. They get surprised when the agent goes toward the belief-inconsistent location and can predict where she would search. Therefore, in concordance with this view, infants don't have two different representations, and infants don't ascribe a different belief to an agent. One of the representations is considered to be the strongest due to encoding with an agent. Thus, what is expected to happen in implicit ToM is that infants themselves represent the event coded with an agent. in fact, the representation of the object and its memory strengthens when socially cued. The same result has been found in studies measuring infants' memory. Therefore, based on this theory, infants should remember the object's location better in a socially cued condition rather than nonsocial (Southgate, 2019; Southgate et al., 2007).

The A-not-B task mainly measures the object location memory; therefore, it could be a good setup to test whether a social setting could modulate this memory or not.

Social influence on A-not-B error

On the other hand, recent studies have been interested in the influence of social cues on the error made by infants in the well-known A-not-B task. In this task, infants witness that an object is hidden in one of two locations. After a short delay, they are encouraged to retrieve the object, which they usually do correctly. After several times hiding in the same location (known as location A), the object is hidden in the second location known as location B (Gratch & Landers, William, 1971). Even though infants witness this location change, most of the 8 to 10 months old infants continue searching for the object at location A if they have been forced to wait a few seconds. One of the studies assessing the influence of communication on the A-not-B task is performed by Topal. He designed the traditional A-not-B in three different ostensive communicative (OC), non-communicative (NC), and nonsocial (NS) conditions. The result showed that 10-month-old infants make an error on 41% of the B trials; the error increases to 81% with social cues. Based on this result, it was concluded that infants have better function and commit minor errors in nonsocial rather than ostensive communication conditions. He stated that based on natural pedagogy, the A-not-B context could have two different interpretations, a hide-search game, which informs infants about the object's location, a correct interpretation or a learning situation in which infants conclude that a specific object could be found at location A (Topál et al., 2008).

By having a closer look at the data driven from his experiment, the interpretation has severe problems. First, error-run haven't been measured. Error run is a reliable variable that shows infants' decision confidence (Goupil & Kouider, 2016). It is essential in the A-not-B task to provide information regarding the infants' expectation about object's location, probably independent of the motor decision (Dunn & Bremner, 2020). They instead computed the percentage of the correct choice in both A and B trials. Then compared the drop in the correct response rate from A to B in each condition. It was mentioned that the drop in the NS and NC conditions has almost been 50% which could be due to random search. In contrast, they searched more at location A in the OC condition. An interpretation could be that the perseveration has occurred just in OC condition. Two other conditions were unfamiliar situations for infants. In NC, the experimenter's face was oriented 90 degree away from infants. In NS, the experimenter was behind the curtain and moved the object. This wired situation itself could be a distraction that prevents children from attending the task. Therefore, as they mentioned in the paper, the performance was around 50% which could be random (Spencer et al., 2009). Another significant criticism is that there wasn't any explanation for the primary cognitive function in their account, which is one of the critical factors in the A-not-B task.

Recently, another study examining the social aspect of the A-not-B task was done by Dunn. They assess the influence of the gaze-direction of the experimenter on the infant's choice. There were three conditions in B trials, congruent, standard, and incongruent. In the standard condition, the experimenter gazed at the center as before. In the congruent condition, as soon as the object was hidden at location B, the experimenter continuously gazed at it during the delay and search phases. In incongruent gaze conditions, the experimenter directed eye gaze to the A location after hiding the object at B. The result showed a significant difference in the errors made in A and B trials in standard and incongruent conditions. Still, there isn't much difference in accordance incongruent one. The reason could be the decrease of memory demands for the correct location while the experimenter gazes at it. Moreover, this study showed the importance of the social cue in the A-not-B setting and how it could improve infants' performance and decrease any error (Dunn & Bremner, 2020).

The results of another study explain the importance of social information during the A-not-B task using different experimenters. Werchan et al., in a series of studies, has shown that an association between the identity of the experimenter and the remote location diminishes the memory load in B trials (Werchan & Amso, 2020).

Therefore, according to recent studies, the A-not-B task's social setting could influence the infant's performance.

Theories behind A-not-B error

Object permanence

Piaget has introduced the A-not-B task for measuring object permanence in his book "the construction of reality in the child" and concluded that infants don't understand the independence of the objects from their actions on them (Piaget, 2013). He hypothesized that object concept development goes through six stages in early childhood, with object permanence in the fourth stage at about nine months of age (Huitt & Hummel, 2003). In Object permanence understanding, when an object is occluded by something else, there are three assumptions: 1- the occluded object still exists 2- it still has the physical properties it had before 3- it still follows the physical properties (Evans & Gratch, 1972). Like ToM studies, the VoE technique changed the knowledge in this realm.

In the 'drawbridge' task, a flap was lying on the table while the terminal edge was nearer to the child (Renée Baillargeon et al., 1985). The flap begins to turn 180 degrees and then lies again on the table, with the hinge closer to the child. After becoming familiarized with this procedure, a cube is placed in the path of the flap. Then, the infant saw either the same design or partial rotation due to contact with the cube. Surprisingly, the infant looked longer at the 180-degree turn, even though it was similar to the familiarization phase. The author concluded that infants are aware of the continuity of the object and the physical rules that apply even when it is out of sight (Renee Baillargeon, 1986). In another study, infants looked longer when the car came out from behind the screen while a box was impeded its way. Several other studies have shown that infants have core knowledge of the object concept (Spelke et al., 1992; Spelke & Kinzler, 2007). According to this evidence, the reason for conducting this error is not merely related to lack of object-permanence. Additionally, this method, by measuring implicitly, revealed that children have correct expectations even at a younger age, but they can't perform accordingly in direct measurements.

Underlying Cognitive process

Memory

Memory is considered to be highly involved in the A-not-B error because, without any interval, infants can find the object. As soon as some delay imposes, they start to err (Bjork & Cummings, 1984; Adele Diamond & Doar, 1989; Graber et al., 1989). Diamond found that changing the delay time can profoundly influence the infant's performance. Also, the error can increase or decrease due to other memory demands, which we will discuss more in "Various factors influence the A-not-B error" part. Therefore, memory is one of the influential factors in perseveration error.

As children have immature brains and limited cognitive resources, some researchers hypothesized that the B trials have weaker encoding because consecutive A trials already occupy the limited working memory. It has also been explained that the former restored events are mistakenly considered the latest ones, and decisions are made based on them (Sophian & Wellman, 1980).

Attributing memory deficit to the infants has been sometimes criticized by the evidence from the tasks measuring more directly infants' memory. The important thing that should be noticed is the A-not-B task isn't a simple memory measuring task. In this task, infants need to update their previous information, but they should also keep this update in their working memory. According to this perspective, even infants can update their representation; they can't keep them or access them for a long time because their memory is susceptible to interference proactively. Infants can perform memory tasks and update the representation correctly (changing the object's location several times), but the A-not-B task requires them to do both simultaneously, which is not plausible due to infants' limited cognitive function. Perhaps this is the reason for increasing the delay time as infants grow. Some other theories argued that both representations for location A and B are still available, but infants choose wrongly because of stronger memory for location A. On the other hand, some scientists, who agree with exciting both representations, have attributed the error to children's response selection mechanisms.

Memory + Attention

Some studies have argued the role of attention in this error (Abrams & Dobkin, 1994; Perner, 2020). For many years, it was believed that attentional flexibility and allocating proper attention to the sequence of events during the A-not-B task could influence the function (Mulder et al., 2020). In most of these theories, memory is always included. A trial due to repetition has grabbed more attention and therefore stored in long-term memory, whereas the B trials get less attention and are still in short-term memory. The perseveration results from competition between these two memory traces (Wellman et al., 1986). Horobin and Acrcdolo found that infants who attend location B are less likely to make errors. They believe that AB errors happen due to insufficient attention while changing location (Horobin & Acredolo, 1986).

In a closer look at the A-not-B task, it is noticed that for the correct retrieval, not only is it necessary to recall the correct location but also to reach correctly (Ahmed & Ruffman, 1998). Consequently, some theories have focused on searching behavior and its underline mechanism to explain A-not-B error.

Inhibitory control

Some other researchers believe this error happens due to the Infants' inability to inhibit the previously learned motor activity (Mauerberg-deCastro et al., 2009; Spencer et al., 2001). They argue that the physical act is crucial for making an error. The basic assumption is that children plan their movement egocentrically, based on their own body (J Gavin Bremner, 1978), not the object's location. Because of this, if the participants' position is changed 180 degrees around the table where the task is performed, they reach correctly to location B (J. G. Bremner & Bryant, 1977). However, the problem with this approach still could not clarify the discrepancy between looking and reaching behavior. Children could not be egocentric just in reaching level and not at looking. In this regard, some researchers believe in two dissociate systems for looking and reaching. While Thelen et al. proposed the dynamics of action planning, he has claimed that according to the unified field, the fundamental notion for embodiment cognition, looking, and reaching are coupled and started to question the distinction between merely computational cognition and physical aspects of behavior (Thelen et al., 1993, 1996). Convergently, some other studies have shown changing the position of children from sitting to standing, sitting on dense or pliant foam (Berger et al., 2019), adding weights to infants' arms before switching the location can decrease the error run (Smith, 2005). Dynamic System Theory (DST) states a difference between what infants know and do (Spelke, 1990). DST explains the A-not-B error as the production of various causes interacting over the decision time (Burns & Domjan, 2001). This approach considers the interactions between previous memory representations and the current representations of the body in the environment, which has caused DST to be considered a notion for embodiment cognition during humans' development (Glenberg et al., 2001). The fact that cognition is embodied means that it is made by the Interaction of the body with the environment (Lindblom, 2020). For instance, most memories are made by perception-action, the Interaction of the body in the environment. Considering the A-not-B task setup, infants visually represent the object's hiding location. The brain performs a motor-planning considering the spatial location of the body in the physical environment and then implements reaching in behavioral level. As the attentional source of infants is limited, if infants' position wasn't stable (sitting on the pliant foam rather than dense), they will make more errors. This is due to cognition-action trade-offs, and a behavioral manifestation of embodied cognition (Berger et al., 2019). In lack of competition, infants will make a sensory-motor decision to retrieve the object. Repeating this procedure makes a stronger memory for this motor movement. It is plausible that after changing the location, even while the infants are looking at location B and may know that the object is there, they make the error due to the cognition-in-action essence of the A-not-B task. Considering the embodied nature of cognition makes it easier to understand the A-not-B error and the various factors that can influence the result (Spencer et al., 2001).

Different Response modalities (Looking versus Reaching)

Additionally, some studies test infants' looking behavior in A-not-B tasks. Diamond showed that some infants even reach wrongly to A but gaze at B. In the other study, infants looked at the correct location more likely than reaching it (Adele Diamond, 1988) . The A-not-B task will change if the measured response modality has been changed. As mentioned above, one of the methods for visual measuring is the violation of expectation. Hiding an object behind the screen and later retrieving it from correct (possible) or incorrect (impossible) locations have been studied via looking measures (Hofstadter & Reznick, 1996). It has been shown that the infant's memory could recall the location even after 70 seconds; these studies have concluded that A-not-B error couldn't be due to the fragile memory of children (Graber et al., 1989). But these studies have been more straightforward than the A-not-B task because there wasn't any interference from previous memory traces. In the A-not-B version, the object isn't simply hidden and retrieved. It is hidden and retrieved at location A several times and then hidden at B. This makes a strong memory for the object at that location or for the motor activity. To assess this criticism, some researchers measured looking behavior but, in a situation like traditional A-not-B. Infants watched the object hidden and retrieved it several times at location A. Then hid at location B and retrieved it from either location A or B (possible or impossible). As infants could pass the A-not-B task in these tasks, it was assumed that looking is not vulnerable to perseveration like reaching (Ahmed & Ruffman, 1998).

This inconsistency between the two measurements could be due to the immature prefrontal cortex. Patients with lesions in this area sort carts in Wisconsin tasks incorrectly while saying they are doing incorrectly. On the other side, from an anatomical point of view, the area responsible for perseveration is the prefrontal cortex. The evidence comes from the study with monkeys that have dorsolateral lesions. The result showed the perseveration in the performance of this population in the delayed response (DR) task. DR is similar to the A-not-B task, except that the location change doesn't happen after several consecutive A trials; it changes randomly (Adele Diamond & Doar, 1989; Johnson & O'Gilmore, 1995). Therefore, Studies of patients and monkeys with a lesion in the prefrontal cortex give another reason to attribute the perseveration error to the prefrontal area.

Additionally, the function in the A-not-B task improves over the first year of life. This area is mainly responsible for higher Executive function, inhibition mechanisms, and selecting relevant stimuli to attend to. The information interference in infants could be due to undeveloped dorsolateral areas. Another theory suggested that distinct brain areas are involved in visual and manual responses. The prefrontal cortex takes two different pathways to make a manual or visual response (Hofstadter & Reznick, 1996).

Given that infants have a better outcome in violation-of-expectation could be explained differently. Besides the immature prefrontal cortex and different neural pathways that seem to impact motor planning more than looking behavior, there are other explanations. Some theories argue that the repetition of a motor activity makes it a skill that would be the first option to act in the same situation. But there isn't such a skill in looking (Abrams & Dobkin, 1994; Hofstadter & Reznick, 1996). The first assumption is that infants have the knowledge about the actual location of the object, but its interferences with previous knowledge; therefore, it is not accessible for infants in the manual task. The second assumption is that these methods measure two different concepts. VoE measures a reaction rather than a response because infants don't reach any location instead passively look at an event. In other words, the mechanism behind the VoE is a reaction by activating recognize memory, but the manual task is related to recall memory. Therefore, it wasn't clear whether children who make errors in the manual version know the object's location or not. According to a group of ideas, they know that the object is at location B but recent information interferences with previous ones. As this interference is more robust in motor planning, it causes errors in manual tasks. Based on this notion, the knowledge needed to pass the manual task is the same as the looking-measure tasks.

Nevertheless, some theories attribute the error to object-permanence but differently from Piaget. In a view proposed by Munakata et al., it was supposed that the object-concept isn't an available or not available construct in mind. Object-concept is a representation of the object in the mind which could change due to environmental factors like accessibility. This internal representation could strengthen and influence manual behavior. Based on this notion, the contradiction between measuring looking and manual results is that manual response needs more robust representation than looking. Reaching correctly to location B requires an active representation of the object in that location. Active representation of an object in a location needs to attend there. Searching several times at location A makes it a salient stimulus to attend, which captures the attention more even during B trials and prevents having a solid representation of object at location B (Munakata, 1998).

Another explanation for the inconsistency between manual and looking tasks is the types of knowledge that each modality needs. Dienes and Perner have suggested two implicit or explicit representations of knowledge. Implicit knowledge is a kind of knowledge shown in indirect measurements, and there isn't any control for applying it (Dienes & Perner, 1999). It seems infants pass the looking tests relying on their implicit knowledge.

While some researchers try to explain the inconsistency between looking and reaching modalities, others reported almost the same results. Hofstadter and Reznick reported that only in 14% of the cases, the manual and looking behavior weren't matched, and in 9.4% of this, the looking behavior was correct. However, Ahmet et al. showed that this mismatch between looking time measure and reaching is almost 55% (Ahmed & Ruffman, 1998; Hofstadter & Reznick, 1996).

Various factors influence the A-not-B error

Many studies have been manipulating different factors to find out more about the nature of the A-not-B error. Below, some of these factors have been reviewed.

Age: A large body of studies shows that children's performance improves in AB tasks as they grow. This could be due to brain maturation, as the AB task is similar to the response delay task. As the infants are grown on, longer delay times are needed to conduct the error. In a series of studies, Diamond showed that this error occurs first at eight months. After that, 2 seconds per month should be added to delay time to cause an error. More than this could cause a random performance of infants (A. Diamond, 2001; Graber et al., 1989).

Delay time: As the delay time increases, the probability of making an error is also increased. Still, there is a threshold here, which means that infants' performance would be random if the delay increases (A. Diamond, 2001).

Identical/distinctive Locations: The similarity between two hiding locations also influences the error run. When wells are distinctive, infants are less likely to make errors (Marcovitch & Zelazo, 1999).

Distance of wells: Horobin and Acredolo, in a series of studies, have shown that the spatial separation of wells is one of the most critical contributors to errors. The error is much more likely to occur when two locations are close to each other. Because being close to each other makes infants' attention wander from B to A, previously attended location (Horobin & Acredolo, 1986). This factor could also be related to memory; a spatially close location is more complicated.

Number of A Trials: In the metanalyses done by Wellman et al., they didn't find the number of A trials influencing the error run. Later in another meta-analysis done by Marcovtich, he showed that "the number of A trials is a significant predictor of the proportion of infants who searched perseveratively" (Marcovitch & Zelazo, 1999, 2006; Wellman et al., 1986).

Number of Locations: The influence of the number of hiding locations was the same as the number of A trials in Marcovitch meta-analyses (Marcovitch & Zelazo, 1999).

Summery and Hypothesis

There is an inconsistency between implicit and explicit ToM findings. Altercentrism theory claims that infants pass implicit tasks because their object representation is based on the agent's view. The event encoding together has more salient memory than encoding alone. A-not-B is an object location memory task. We hypothesize that the presence of a social agent who witnesses the object transferring from location A to B (social condition) with the infant will reduce the error compared to the condition that the infant witnesses alone (nonsocial condition).

Study 1

(A-B task with 20s interval)

Methods

Participants

For the first study, there were 15 participants (Iranian kids, 20 to 36 months old, mean = 26.66, SD = 6.65, nine girls, six boys). Three participants were excluded due to not completing the whole experiment (1 kid, 24 months old), not cooperating (1 kid, 20 months old), not doing two consecutive successful A trials after five repetitions (1 kid, 32 months old). The participants are recruited through online advertising in social media among families in Tabriz (one of the five biggest cities in Iran). Volunteer parents should have access to a laptop and a high-quality internet connection. After contact with the experimenter, parents have received an explanation of the procedure. They received a link to fill out the consent form and EEFQ questionnaire on the Labvanced platform if they were interested.

Apparatus

The experimenter sat in front of a laptop. She had a signed area in front of her on the table to put the toys and tunnels to ensure that camera would show them at the same distance. There was also a belt (a rig of 10-centimeter width paper around the table used to move the abject alongside the table's width) at a 15-centimeter distance from the edge of a table. It was possible to put a toy on the table and move it from one edge to another through the belt. Even the experimenter was the one who pulled the belt under the table; it was entirely invisible for the viewer.

There were two specified places for the tunnels at the same distance from the midline and the experimenter. Tunnels were almost cubic shape boxes with only four sides. One side of this box was open so that the toy could enter inside it (all other sides were close; therefore, the toy was hidden entirely after entering it). The bottom side was also missing; therefore, the belt on the table could move beneath it without moving the tunnel itself. There were three different pairs of tunnels for familiarization, social and nonsocial conditions. Boxes were designed so that while putting each pair on the table, the open sides of them were facing each other. It was possible to move the toy, hidden inside one tunnel, toward inside the other. Four different toys (duck, cow, ball, truck), two for the familiarization (always duck and cow), one for social, and one for nonsocial were provided.

In the traditional A-not-B task, the wells are usually used, and in each trial, the experimenter puts a toy inside one of the wells. We aimed to test the influence of social witnessing in location change trials. To investigate this hypothesis, two different conditions were needed. In one condition, which we called Social, the location change occurred while the experimenter witnessed it with the child, and another, we called Nonsocial, the child witnessed it alone. Considering this hypothesis, we designed this new setup with tunnels and belt to avoid having different variables. Using the belt and tunnels made it possible to change the location in nonsocial conditions. Therefore, all trials in social and nonsocial conditions were done in the same way except that the social one witnessed by experiment.

Procedure

The experimenter made a video call on Zoom or Jitsi software with parents. The parent with the child in his/her lap sat behind the laptop at a distance that the child could easily see the screen, and the experimenter could see the child's hands. Parents were instructed to: Make the experimenter's video full screen and close their own, Stay completely behind the child (not beside him/her and looking together), Not interfere during the experiment, except when the experimenter asks about the child's pointed location, in case the experimenter couldn't realize the side.

The task order for each kid was:

- ✓ Familiarization
- ✓ Removing the tunnels and the toy from the scene, bringing new pairs of tunnels and a new toy
- ✓ A trials until the child points correctly in two consecutive trials
- ✓ B trials (social or nonsocial) until the child points correctly
- ✓ Removing the tunnels and the toy from the scene, bringing new pairs of tunnels and a new toy.
- ✓ A trials until the child points correctly in two consecutive trials
- ✓ B trials (social or nonsocial) until the child points correctly

A trials were identical, but B trials differed in one aspect, our main variable, social witnessing. Their order was (first social or nonsocial) counterbalanced among participants.

Familiarization

The experimenter showed two animal toys to the child, shook them to grab his/her attention, made the sound of that animals, kept them close to the camera while asking the child which one he liked more to continue playing with. She kept the toys close to the camera while encouraging the child to select one and show his/her choice by pointing at it. This phase was done for familiarizing the baby with pointing. In case the infant didn't point at any toy after several times encouraging or changing toys, the experimenter asked the parent to point at a toy. After choosing the toy, the experimenter puts the toy in the midline on the belt. She asked the child to look at the toy. Then pulled, the belt under the table (not visible for the child) to move the toy toward one of the tunnels (the left or right side was counterbalanced among participants, and the side of the upcoming A trials was the same as the Familiarization side). When the toy reached inside the tunnel Experimenter looked at the camera while asking the child where is the toy? When the child pointed correctly, the experimenter held the tunnel, got excited, encouraged the child while clapping and cheering; otherwise, she repeated the procedure a maximum of 2 more times.

A trials

A trials were the same in both social and nonsocial conditions. The experimenter brought a toy, shook it in front of her face to gain the infant's attention, put it on the midline, and then moved it toward the tunnels (the same direction in the familiarization) while following it on the belt with her eyes. As soon as the ball reaches inside the tunnel wholly hidden, the experimenter picks an animal photo to hold it close to the camera to cover the boxes. She moved the photo in front of the camera while saying the name of the animal and later making the sound of the animal. Neither of the tunnels was visible for the child for 20 seconds. After the 20 seconds interval, the experimenter took the photo out of view and asked about the hidden toys' place. When the child pointed correctly, the experimenter lifted the tunnel, got excited, shows the toy to the child while clapping and cheering. When the child did wrong, the experimenter lifted the tunnel, saying," it is not here." Then she lifted the other one to show the toy's location to the child. Anyhow Experimenter starts the procedure again until the child points to it correctly on two consecutive trials for a maximum of 5 trials.

Social B trials

After two consecutive A trials, the experimenter put the toy in the exact location (midline) and did the same procedure as the earlier A trial. As soon as the toy reached inside the tunnel (the same side of A trial), completely hidden, the experimenter held her phone and told the child that she had to talk on the phone. She turned back, pretending to talk on the phone. Then she turned back to the camera. The belt was moved, and the toy was transformed into the other tunnel (from location A to B) while the experimenter was gazing at the toy all the way to change location. As soon as the toy reached inside the tunnel, the experimenter did the distraction part for 20 seconds. This procedure is continued until the child points correctly (once in a maximum of five trials).

Non-Social B trials

After two consecutive A trials, the experimenter put the toy in the exact location (midline). The procedure started as same as the previous A trial; the toy moved toward the tunnel (same tunnel as previous A trials). As soon as the toy reached inside the tunnel, wholly hidden, the experimenter picked up her phone and told the child that she had to talk on the phone. She turned back and pretended to talk on the phone. Meanwhile, the toy was transferred through the belt to the other tunnel (from location A to B) while she was still back to the camera. Therefore she didn't see this location change of the to. As soon as the toy reached inside the tunnel, she turned back to the camera and did the distraction part for 20 seconds. Nonsocial B trial was repeated until the child pointed correctly (once in a maximum of five trials).

Error run

Various studies have measured the A-not-B error differently. Some of them have determined the fixed number of A and B trials and have compared the proportion of correct choices for each. We chose the error run, which counts the number of incorrect choices in B trials until a child chose the correct side (The number of trials the infant pointed incorrectly before choosing the correct location)

Result

Error run was calculated. One of the participants made three errors but later 2 successful constrictive in the first A trials. Two of them made one error in the second A trials. In B trials despite the condition four participant made error. First, Mann – Whitney U tests were used to determine the differences in error run on B trials between groups based on A location (left or right) and order of conditions (social or nonsocial) on A and B trials. No significant differences were found ($p = 0.79$).

In B trials, one participant made an error in the social condition and two in the nonsocial condition. One of the participants made an error both in social and nonsocial conditions. In Total, we had two kids in social and three kids in nonsocial conditions with one error (see plot 3). A Wilcoxon signed rank test comparing error runs in two conditions was conducted to test whether children made more errors in the nonsocial compared to the social condition. This yielded no significant difference (as a few participants made error the median is 0 for both social and nonsocial condition, mean error-run social = 0.18, mean error-run nonsocial = 0.27 $p = 1$).

To ensure that children's performance in the A trials did not differ between the two conditions, a Wilcoxon signed rank test was conducted (as a few participants made error the median is 0 for both A trials, mean error-run for first-round A trials = 0.18, mean error-run for second round A trials = 0.27 $p = 1$ $p = 0.82$) there wasn't any significant difference.

Discussion

Subsequently, just a few kids made errors in B trials. As the perseveration error didn't significantly occur, it wasn't plausible to test the influence of the social agent on the rate of errors. The first assumption for this experiment was the significantly more error in B trials than A, which usually occurs in A-not-B. in our sample; the participants have almost the same performance in A and B trials. There could be different reasons for not committing perseveration errors. We decided to review and modify some influential factors and perform another study.

The various factors influencing the error were already discussed in the introduction. We decided to change some of them while being cautious not to make the task tedious. As age is one of the essential factors in committing an error, the first modification was decreasing the age of participants. We started recruiting the younger kids (those younger than 17months old couldn't collaborate and point; therefore, we recruited 18 to 25 months old). Another influential factor is the delay time. In fact, by letting infants reach the toy as soon as hiding, the error doesn't accrue even in 8 months old. The delay time increased from 20 to 30 seconds.

Additionally, as the error happens due to improper attention and memory interference, we changed the type of activity during delay time to add more cognitive demands. Before, it was showing an A4 page size color printed animal photo and making its sound. The new version was presenting a photo of daily life and asking the child to show a familiar object like a TV, birthday cake, or a boy in it. Doing a distractive task could weaken the memory trace of the previous event or wander the attention from the last side the object was hidden. To sum up, three modifications were applied: Decreasing the sample's age, Increasing the time interval, Changing the distraction task. All these factors could add more demand on memory and cause the error

Study 2

(A-B task with 30s interval + distraction task)

Method

Participants

For the second study, there were 18 Iranian participants, age range 17 to 25 months old (mean=19.83, SD= 3.2, 9 girls). Nine participants are excluded due to not completing the whole experiment (3 kids), not cooperating (1 kid, 20 months old), technical problems (internet connection two kids, camera, or microphone problem two kids). The participants are recruited through online advertising. Volunteer parents should have access to a laptop and a high-quality internet connection. Parents received a link to fill out the consent form. After recruitment, they also received a link to fill out the EEFQ questionnaire on the Sosci survey platform.

Apparatus

Three pairs of tunnels, four different toys, a duck, a cow, a ball and a truck, a commuter belt from study 1 were used here.

Procedure

The number and order of the trials were the same as in study one. We increased the delay time from 20 to 30 seconds based on the discussion. Therefore, the toy was hidden in one of the tunnels several times until the child pointed correctly in 2 consecutive trials.

Familiarization

This phase aimed to teach the child to point and familiarize him/her with the upcoming task. We did this phase the same as the first study. After familiarization, we had A trials and social or nonsocial conditions (counterbalanced).

A trials

A trials were the same in social and nonsocial conditions. The experimenter brought a toy, shook it in front of her face to gain the infant's attention, put it on the midline, and then moved it toward the tunnels (the same direction in the familiarization) while following it on the belt with her eyes. As soon as the toy reached inside the tunnel, wholly hidden, the experimenter picked a photo hold it close to the camera to cover the boxes. Neither of the tunnels was visible for the child for 30 seconds. The experimenter asked the child to show familiar objects in the photo to distract the child. After, the experimenter took the photo away and asked about the hidden toys' place. When the child pointed correctly, the experimenter lifted the tunnel showed the toy while clapping and cheering. When the child did wrong, the experimenter lifted the tunnel, saying," it is not here." Then she lifted the other one to show the toy's location to the child. Anyhow Experimenter starts the procedure again until the child points to it correctly on two consecutive trials for a maximum of 5 trials.

Social B trials

After two consecutive A trials, the experimenter started B trials. As soon as the toy reached inside the tunnel (the same side of A trial), the experimenter picked her phone up and said that she had to talk on the phone. She turned back, pretending to talk on the phone. Then she turned face to the camera. The belt transformed the toy into the other tunnel (from location A to B) . As soon as it reached inside, the experimenter did the same distraction part for 30 seconds. This procedure is continued until the child finally points correctly (once in a maximum of five trials).

Non-Social B trials

After two consecutive A trials, the experimenter put the toy in the exact location (midline) and did the same thing as before. As soon as the toy reached inside the tunnel wholly hidden, the experimenter picked up her phone and told the child that she had to talk on the phone and back, pretending to talk on the phone while she was back to the camera. Meanwhile, the toy moved through the belt to the other tunnel from location A to B). Then she turned back to the camera and did the same distraction for 20 seconds. The procedure was the same in social and nonsocial conditions. B trial was repeated until the child pointed correctly (once in a maximum of five trials).

Result

Error run was calculated for each child in each condition. For the first session of A trials, four participants made an error. They all pointed wrongly in the first trial but correctly in the latter two consecutive trials. Three participants made the same first A trial mistake in the second round. In B trials, despite the condition, two participants made an error. First, Mann – Whitney U tests were used to determine the differences in error run on B trials between groups based on A location (left or right) and order of conditions (social or nonsocial) on A and B trials. No significant differences were found ($p= 0.79$).

To test whether children made more errors in the nonsocial compared to the social condition, a Wilcoxon signed rank test comparing error runs in each condition was conducted. This yielded no significant difference (as a few participants made error the median was 0 for both social and nonsocial condition, mean error-run social = 0.11, mean error-run nonsocial = 0.11 $p = 0.20$).

To ensure that children's performance in the A trials did not differ between the two conditions, a Wilcoxon signed rank test was conducted (as a few participants made error the median is 0 for both A trials, mean error-run first round A trials = 0.18, mean error-run second round A trials = 0.27 $p = 1$ $p = 0.82$). The result yielded no significant difference as expected (see plot 4).

Discussion

Again, just a few kids made errors in B trials. As already mentioned in study 1, if the perseveration error doesn't occur, it isn't plausible to test the influence of the social agent on the rate of errors. The first assumption for this experiment is more significant errors in B trials which usually occurs in traditional A-not-B. In the second sample, despite the modifications (the mean age of the participants decreased from 26.66 in study 1 to 19.83 in study 2), the perseveration still didn't occur. There could be different reasons for not committing perseveration errors. As we already had manipulated every plausible factor, it wasn't possible to do more in online mode.

General Discussion

The main hypothesis of the current study was to investigate whether infants remember the new location (B) better if they witnessed the location transferring together with the experimenter? We designed social and nonsocial conditions in B trials of the A-not-B task to test this hypothesis. The only different variable between these two conditions was the experimenter's witnessing. In social conditions, the experimenter gazed at the object while it was moving toward location B, while in nonsocial, she didn't see this transferring, and the child witnessed it alone.

We expected to find the difference because, according to Southgate, memory for the object's location from the perspective of the experiment is more strengthened than infants' own perspective (Kampis & Southgate, 2020; Southgate, 2019). Howard et.al's study showed that agentive actions have more robust memory than mechanical ones. In a series of studies, he showed that infants learn better in the presence of an agent rather than she was absent. To ensure that it wasn't just due to attentional difference, he performed a similar experiment with eye-tracking again infants' memory was robust for social agent present condition. Furthermore, the event-related potential paradigm showed the memory-related component in two different conditions (present or absent social agent)(Howard et al., 2020; Howard & Woodward, 2019). Resent study couldn't find a significant difference between social and nonsocial conditions. We overall found minimal perseveration errors across experiments 1 and 2 with different variations, which made it difficult to see differences between the conditions. Children in our experiment barely made the error. The assumption to test this hypothesis was the usual outcome of the A-not-B task, significantly more error in B trials than A. this assumption wasn't present in our study due to the ceiling effect; a high proportion of subjects obtained the maximum score, which made the discrimination between conditions impossible.

The most important reason for the ceiling effect was the age of our participants. Regarding the factors influencing A-not-B error, the crucial factor is age. The A-not-B error happens around 8- to 10-month-old with almost 2 second delay time. A previous scientific paper has shown that older children are also susceptible to making an error by increasing the delay time (almost two seconds for each month after the 8th month). Regarding our experiment to be practical in the online version, we needed infants above 18 months (in our preliminary pilot with had16 months old infants, but they weren't able to collaborate with pointing). A-not-B task has already been performed with 18 months old infants with a five-second delay and four A trials. The age range for study 1 was 18 to 36 months (mean = 26.66, SD = 6.65). as the perseveration error wasn't significant in the first study for the second one, we decreased the age range (18 to 25, mean=19.83, SD= 3.2). The new result also showed the ceiling effect, which is worth mentioning again that we couldn't test younger infants online.

Other influential factors of the A-not-B task are the number of A trials, time interval, the number of locations, the distances between locations, and the visual properties of the hiding. Several metanalyses have studied these factors (Marcovitch & Zelazo, 1999; Wellman et al., 1986). In the one done by Wellman et al., they found that age, delay time, and the number of hiding locations strongly influence infants' performance. The number of A trials wasn't among them. A later meta-analysis by Marcovitch revealed that the number of locations predicts the rate of perseveration but not the correct reach. Age and the distance between two locations are positive predictors of the correct response, and the delay time and the number of A trials are negative (Marcovitch & Zelazo, 2006). For the second study, we also increased the delay time and the type of activity to increase the probability of perseveration in B trials. According to the theories attributing the error to infants' immature memory, increasing the time interval induces more load on memory (Adele Diamond, 1985). Before, it was a passive looking at an animal photo. We changed it to finding a familiar concept in a more complex photo and pointing at it (Mulder et al., 2020).

Another difference in the present design was the movement of the object. Instead of manual movement by the experimenter, the toy was moved through a belt toward one of the tunnels. Yoon et al. showed that while the experimenter points at an object, infants remember the object's location but not the identity. When she reaches and grasps it, they remember the identity better (Yoon et al., 2008). In the traditional A-not-B task, the experimenter grabs the toy and puts it in one location. From a neuropsychological point of view, there are two different streams for visuospatial perception (Leslie et al., 1998). Based on Yoon's study, the pointing has activated the *where* stream, whereas the reaching has activated the *what* stream. Pointing and gazing are considered active and passive social referential communication (Pack & Herman, 2004). In the current study, the experimenter did referential communication while gazing at the toy and telling the child to look at the toy. The experimenter didn't grasp the object to hide it manually (unlike the traditional A-not-B task); instead, she just gazed at it. It should keep in mind that Yoon experimented with subjects in early infancy. Our participants were older. It isn’t sure that gazing and grasping work in the same way in later infancy.

Doing a more classic live A-not-B task (not online) with the classical A-not-B age (~8-9 months) and only vary the factor we are interested in, namely, whether the B hiding session witnessed by a social agent or not, is highly suggested.

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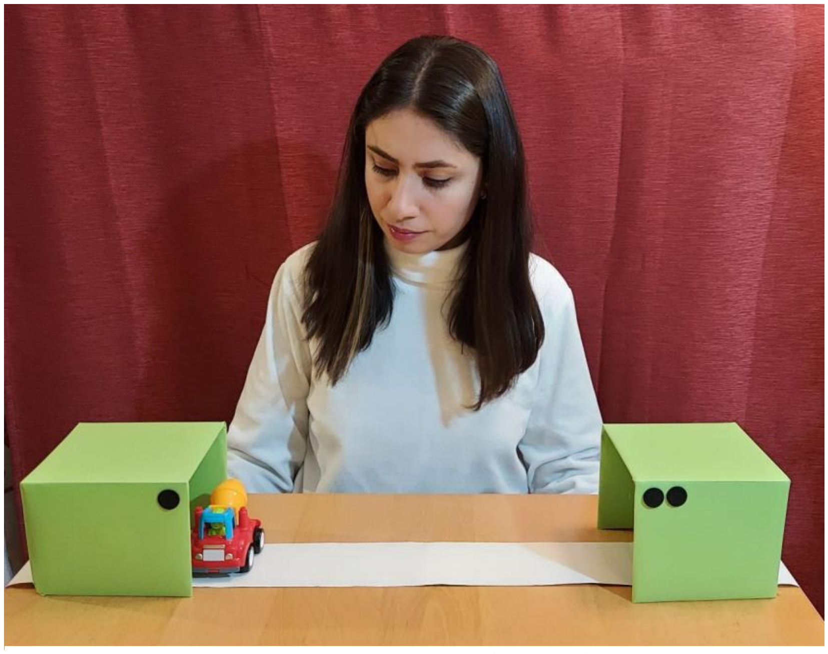

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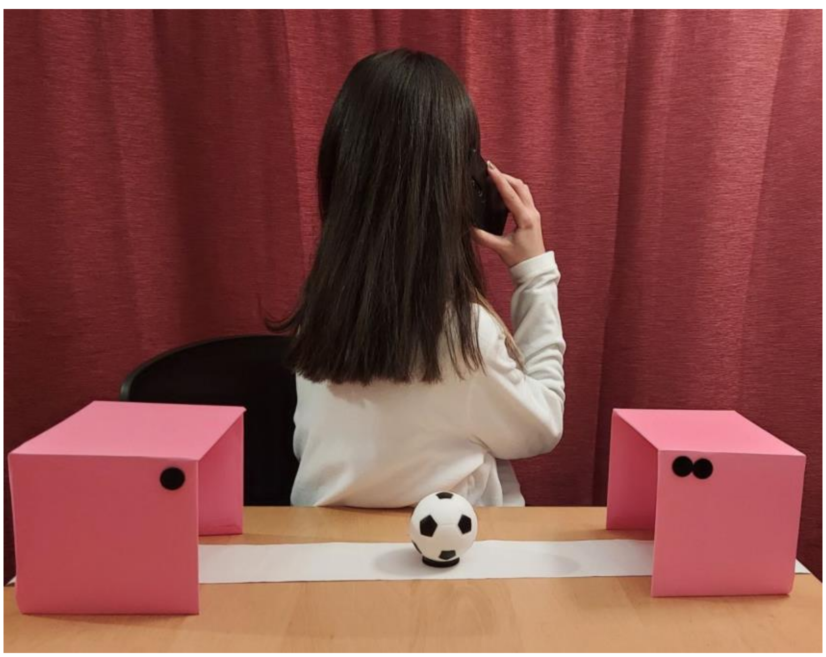

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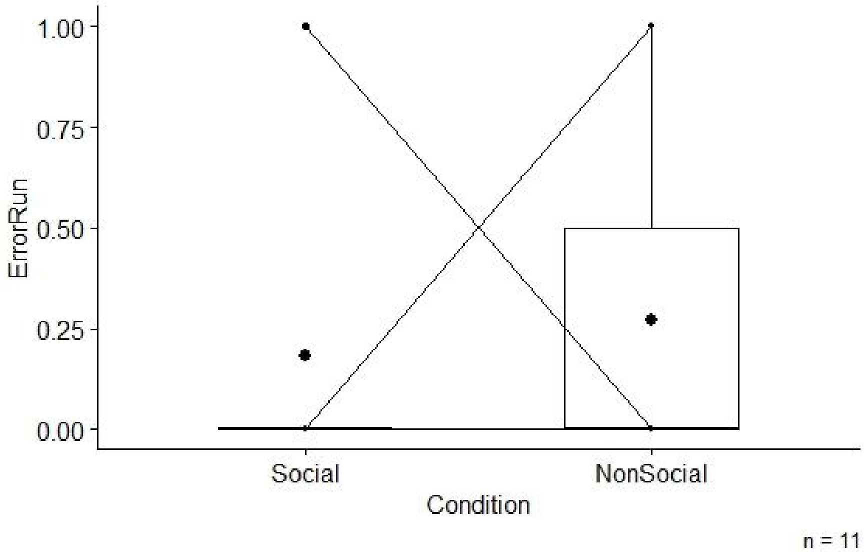

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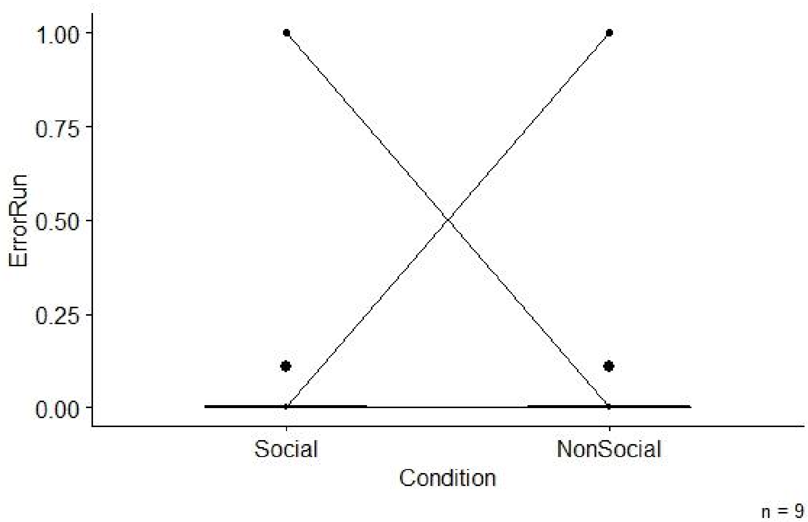

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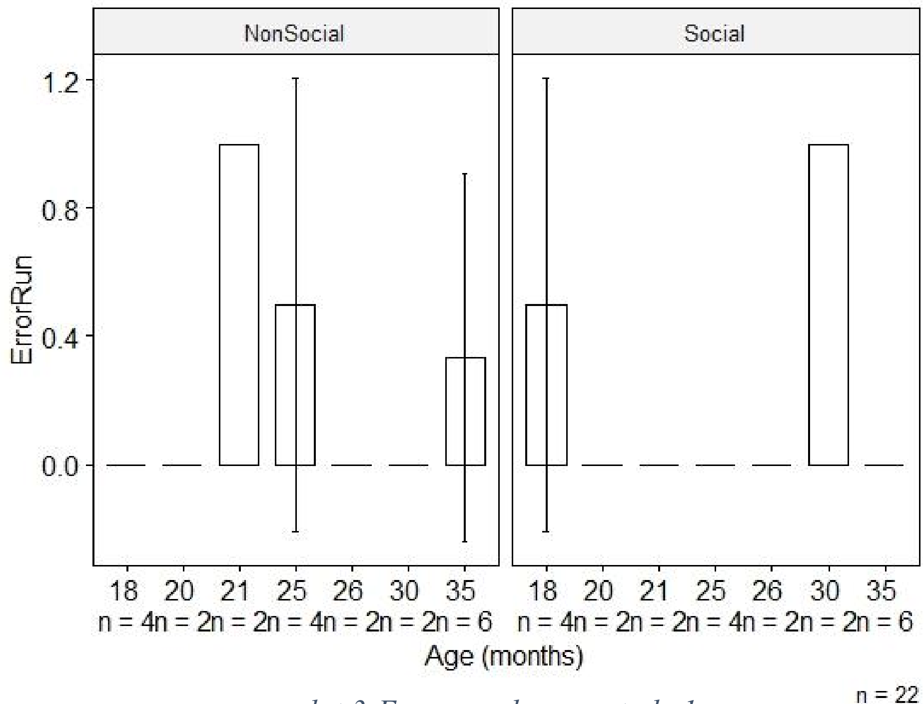

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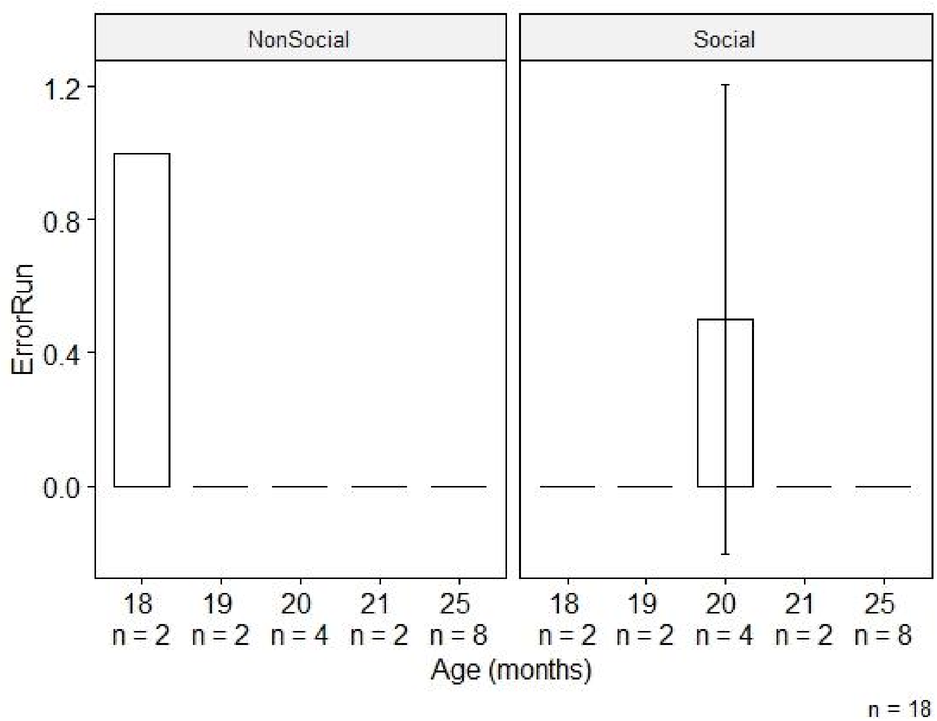

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