An Exploration of Parent-Child Joint Attention During a Problem-Solving Task: A Novel Eye Tracking Method

by

Thuvaraka Mahenthiran

A thesis

presented to the University of Waterloo

in fulfilment of the

thesis requirement for the degree of

Master of Arts

in

Psychology

Waterloo, Ontario, Canada, 2026

© Thuvaraka Mahenthiran 2026

Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Parents play a critical role in helping their young children navigate challenging or novel problems (Ladd & Petit, 2002). Studies show that joint attention (JA) is a key predictor of successful collaboration, which contributes to successful problem solving and learning (Barron, 2003). JA occurs when two individuals coordinate their focus to mutually share attention towards a common event or object (Bradley et al., 2023). Most studies examine JA between infants or toddlers and a parent without considering other aspects of the interaction (e.g., Ambrose et al., 2020; Guo & Feng, 2013). Consequently, there is limited work on how JA relates to parenting behaviours in naturalistic learning contexts. This thesis examines whether the proportion and type (child-led or parent-led) of JA differ depending on the parents' motivational state and whether parental behaviours are associated with JA. I examined eye tracking data from a subset of participants in a larger study (N=29 dyads; child ages 4.00 - 5.83 years) in which parents' and children's eye movements were recorded while children completed three challenging tangram puzzles (modeled after Lunkenheimer et al., 2017). The dyads were randomly assigned to one of two study conditions used to manipulate the parents' motivational states: process-oriented or outcome-oriented. JA frequency and type (child vs. parent led) were coded for predefined regions of interest (e.g., the puzzle boards, parent hand, etc.). Proportion and type of JA was unrelated to motivational state; however, regardless of condition children primarily drove JA during this task. By exploring the dyadic association between parents and their children in a naturalistic task, research like this can inform parents and early childhood educators about how to best support children's problem solving.

Acknowledgements

I would first like to thank my supervisor, Dr. Stephanie Denison who has been guiding and mentoring me since my undergraduate studies. Her unwavering support and confidence in my abilities have had a great impact on my academic journey, and I am especially grateful for her encouragement to pursue and complete my master's degree. I would also like to thank the members of the Developmental Learning Lab for their assistance in this project.

To my fellow graduate students, Ayshe, Salva, Mo and Amy, who have become my closest friends, thank you for making these past two years so memorable. We have shared laughter, tears, and experiences that I will cherish for years to come. Their friendship and support have made this journey all the more meaningful, and I am forever grateful to have had the opportunity to share it with each one of you.

To my graduate mentors, Charlotte, Sarah, Candice, and Claudia thank you for your constant support, guidance and encouragement throughout my journey. Having them all as my mentors has been an invaluable part of my graduate experience. I also want to thank my reviewers Dr. Katherine White and Dr. Heather Henderson for taking the time to read and provide valuable feedback on this thesis.

To my incredible mentors, Dr. Shana MacDonald and Dr. Brianna Wiens, thank you for being my anchor throughout these past few years, providing me with the confidence and support I needed to navigate the challenges of graduate school. I am deeply grateful for the impact you have had on both my academic and personal growth.

Finally, I would like to thank my family and friends for their love, patience and support throughout this journey. Their encouragement has been a constant source of strength and, I wouldn't have been able to reach this milestone without them.

TABLE OF CONTENTS

Author's Declaration ii
Abstract iii
Acknowledgements iv
List of Figures vi
List of Tables vii
INTRODUCTION 1
Self-Determination Theory 1
Parental Motivation and Goal Orientation 3
Scaffolding 4
Joint Attention (JA) 5
Eye Tracking Method 8
PRESENT STUDY 11
METHOD 13
Participants 13
Procedure 14
Coding of JA using Eye-Tracking 16
RESULTS 22
Main Analysis 22
DISCUSSION 28
LIMITATION AND FUTURE DIRECTIONS 32
CONCLUSION 34
REFERENCES 35
APPENDIX A 42
APPENDIX B 45

List of Figures

Figure 1. Image of Second Tangram Puzzle: The Bird 15

Figure 2. Eye-Tracking Visualization of a Dyad 022 Puzzle 1 19

Figure 3. Proportion of Joint Attention by Condition (Process vs. Outcome)..... 23

Figure 4. Joint Attention Type by Condition (Process vs. Outcome)..... 24

List of Tables

Table 1. Description of Parenting Behaviours 21

Table 2. Descriptive Statistics for Core Study Variables 22

Table 3. Correlations with Joint Attention and Parenting Behaviour Variables 25

INTRODUCTION

The development of children's learning and problem-solving abilities is a socially mediated process wherein children are considered active agents who are often supported by a more knowledgeable other (Vygotsky, 1978). As primary socializing agents, parents play a critical role in helping children navigate challenging or novel problems (Grolnick, 2009; Ladd & Petit, 2002). When tasks exceed a child's initial capabilities, parents foster autonomous behaviour by offering encouragement and guidance which enables children to form their own solutions (Grolnick et al., 2002). However, as children develop, they are expected to be more independent in their own learning and problem solving. This thesis explores how parents provide support through JA and build independence during a problem-solving task.

Self-Determination Theory

When parents guide their children through challenging tasks, some encourage independent exploration while others may take a more directive approach. Self-Determination Theory (SDT; Deci & Ryan, 1985) provides a framework for better understanding which of those two parenting behaviours most benefits autonomy-building in children. According to SDT, children's learning motivations can be supported by their innate psychological needs for competence, relatedness, and autonomy (Grolnick, 2009). The need for competence is met when children believe in their ability to succeed, which can be enhanced through environments that provide structure and feedback (Grolnick, 2009; Lerner et al., 2022; Ryan & Deci, 2017). The need for relatedness is met when children feel socially connected to others, which can be encouraged through parents providing resources and maintaining caring and supportive environments (Grolnick, 2009; Lerner et al., 2022; Ryan & Deci, 2017). Finally, autonomous needs are met when children initiate actions volitionally and regulate themselves without

external factors such as rewards and punishments (Lerner et al., 2022). Of the three, the need for autonomy is a key theoretical construct for my thesis because the development of autonomous problem-solving abilities requires children to generate solutions, make decisions and regulate their behaviours independently. As such, factors that influence how these needs are met depend on specific behavioural approaches parents adopt in these interactions (i.e., autonomy supporting parenting versus controlling parenting behaviours).

When utilizing an autonomy supportive approach, parents can provide support by prioritizing their child's perspective, allowing for their initiation and problem-solving attempts, lessening control, and communicating more empathetically while avoiding controlling behaviour and language (Grolnick, 2009; Grolnick & Pomerantz, 2022; Joussemet & Grolnick, 2022; Maurer et al., 2026; Zhang & Whitebread, 2019). For example, when assisting children with homework, parents can ask guiding questions and provide hints when needed (Grolnick & Pomerantz, 2022). However, not all parents partake in consistent autonomy supportive behaviours, and no parents engage in this behaviour at all times and under all circumstances.

Sometimes, parents employ controlling parenting approaches, where they prioritize their own perspectives, add pressure with demands or threats, impose their own solutions, and dissuade input or disagreements from their child (Grolnick, 2009; Grolnick & Pomerantz, 2022; Maurer et al., 2026; Zhang & Whitebread, 2019). For example, when assisting children with homework, parents might provide more directive instructions on how to solve problems and take over completely if the child is facing difficulties (Grolnick & Pomerantz, 2022).

Controlling parenting prevents children from being active agents in their own learning, resulting in lower confidence and motivation in their ideas and abilities (Grolnick, 2009; Zhang & Whitebread, 2019). In contrast, studies have shown that autonomy supportive parenting

positively relates to children's learning, skill acquisition, initiative, and academic performance over time (Bindman et al., 2015; Grolnick & Pomerantz, 2022; Maurer et al, 2026; Ryan & Deci, 2017). For example, a study conducted by Lerner and colleagues (2022) found that children's (aged 9-12) enhanced motivation, school achievement and perceived competence was associated with autonomy supportive parenting but not controlling parenting. Although the benefits of autonomy supportive parenting are well established, less is known about the specific interactional behaviours parents partake in when facilitating the development of autonomy during a problem-solving task.

Parental Motivation and Goal Orientation

The specific interactional behaviours that parents adopt likely depend on the underlying motivations and goals they bring to the dyadic interaction (Moè et al., 2018; Neitzel & Stright, 2003). Individual differences arise based on the extent to which parents prioritize children's intrinsic learning experiences versus focus on immediate task outcomes (Moè et al., 2018). And the context a parent finds themselves in will also impact their behaviours (e.g., when helping a child study for a high-stakes test versus teaching the child a new card game). In accordance with Self-Determination Theory, past studies have demonstrated that placing parents under pressure such that they are accountable for a specific goal-directed outcome systematically impacts their instructional style to elicit more controlling behaviours (Grolnick et al., 2002; Wuyts et al., 2017).

To evaluate how these motivational states impact dyadic interactions, the present study operationalizes parental motivational states into two experimental conditions: process-oriented and outcome-oriented. The process-oriented condition aligns with an autonomy supporting approach where the goal is to promote autonomous learning and task enjoyment (Wuyts et al.,

2017), which in turn is expected to elicit autonomy promoting behaviours such as guidance and encouragement (Grolnick et al., 2002). Alternatively, the outcome-oriented condition is set to create pressure on completing the task successfully (Grolnick et al., 2002; Wuyts et al., 2017). This type of pressure constrains supportive parenting and instead drives more controlling communicative behaviours, such as the use of explicit directives and behavioural intrusions.

Scaffolding

These motivational states ultimately determine the type of structured guidance, often referred to as scaffolding, that parents could provide to support their child's autonomy. While motivation explains the "why" in parents' behaviours, scaffolding explains the "how", serving as the behavioural mechanism used to facilitate a child's learning process (Wood et al., 1976). Scaffolding is described as a form of support where parents, or a more competent individual, tailor their guidance and interventions to a child's zone of proximal development (Vygotsky, 1978). Previous studies have found that there is an overlap between autonomy supportive behaviours and the concept of scaffolding, as both involve structured support that facilitates children's independence and self-regulation (Bindman et al., 2015; Grolnick et al., 2002; Moè et al., 2018).

Effective scaffolding follows the contingent shift approach, where parents continuously adjust their level of support in response to the past successes or failures of their child (Carr & Pike, 2012; Joussemet & Grolnick, 2022). Parents regulate their child's learning by stepping in to reduce task complexity when children encounter difficulty but gradually withdrawing support as children demonstrate success and transferring the responsibility back to the child (Grolnick et al., 2002; Joussemet & Grolnick, 2022). Past research has shown that this use of contingent and responsive support was associated with greater success in problem solving tasks, especially when

assistance was adjusted to the child's region of sensitivity and level of competence (Conner et al., 1997; Pratt et al., 1988; Wood & Middleton, 1975).

Researchers operationalize scaffolding as a multidimensional process that involves cognitive support, emotional support, autonomy support, and the transfer of responsibility from parent to child (Mermelshtine, 2017; Neitzel & Stright, 2003). In turn, effective scaffolding involves a balance of instructional guidance, positive affect, and independence in ways that are responsive to children's changing needs throughout the interaction itself (Grolnick et al., 2002). However, effective support also depends on the quality of coordination between a parent and child during an interaction. In order to provide adequate support that matches their child's current needs, parents must consistently monitor their child's actions and progress. As such, scaffolding is inherently dynamic and depends on moment-to-moment alignment between parent-child attention and behaviour.

Joint Attention (JA)

One mechanism that may underlie this live coordination of attention and support successful scaffolding during problem-solving is joint attention (Hustedt & Raver, 2002). Joint attention (JA) is defined as the coordinated sharing of attention between two individuals towards a common event or object (Bradley et al., 2023). Within parent-child interactions, JA provides a shared attentional window through which partners coordinate their engagement towards task relevant information. Although various terms have been used to describe this shared attentional process, including *coordinated joint attention* (Bakeman & Adamson, 1984), *joint visual attention* (Butterworth & Jarrett, 1991), *triadic attention* (Striano & Stahl, 2005), and *coordinated attention* (Chen et al., 2020), these constructs generally describe the same situation where two individuals coordinate their attention towards a common referent. Thus, the present

study adopts the broader term JA to describe periods during the interaction when both parent and child visually attend to the same task-relevant object.

Joint attention may be relevant for scaffolding because it provides a shared frame of reference where parents and children can coordinate their actions to complete a task. Adult direction and maintenance of children's attention have been known as a central component of effective scaffolding, requiring parents to be sensitive to children's cues and adjust their support based on children's responses to their guidance (Hustedt & Raver, 2002; Landry et al., 1996; Pratt et al., 1988). Additionally, JA has been conceptualized as an indicator of social coordination and co-regulation between a parent and child (Fogel, 1993; Raver & Leadbeater, 1995). By establishing a shared frame of reference, JA allows parents and children to coordinate their actions in a way that creates opportunities for support that is dependent on the child's current needs (Hustedt & Raver, 2002). For example, in one study, Hustedt and Raver (2002) examined 60 mother-child dyads, whose children were around 2-year-old, during a free play task wherein joint attention was assessed. They had found that high levels of JA during free-play task was associated with high scores on measures of maternal scaffolding in the subsequent feeding tasks. These findings suggest that JA may facilitate effective scaffolding because parents must first recognize what their child is attending to and how they are approaching a task in order to provide the support that is appropriately tailored to the child's present needs (Hustedt & Raver, 2002).

Beyond its role in general dyadic interactions between parents and children, JA has also been examined as an important mechanism behind collaborative problem-solving. In collaborative tasks, partners must coordinate their attention, monitor each other's contributions and establish shared understanding of the task in order to work towards a common goal (Barron,

2003; Pöysä-Tarhonen et al., 2021, Schneider & Pea., 2013) As a prerequisite for coordinated interactions, JA is particularly important during solution-critical moments when group members must monitor their own epistemic problem-solving processes while also tracking and responding to others' actions and ideas (Barron, 2003).

In a study conducted by Barron (2003), conversations of twelve groups of sixth-grade students were analyzed as they collaboratively worked on a problem-solving task in order to investigate why some groups were more successful than others and how much they learned. Barron examined how group members coordinated their attention, responded to each other's ideas, and maintained a shared engagement to the problem. Results indicated that successful groups demonstrated greater joint engagement which included attending to each other's contributions and thoughts and building upon shared ideas throughout the interaction. In contrast, less successful groups showed difficulties maintaining a shared focus, as they were more likely to ignore or reject contributions from their team members. These findings demonstrate that establishing JA may be an important process for facilitating a shared problem-solving space, allowing group members to coordinate information and work towards a common goal.

Additionally, within a parent-child dyad, the way in which JA is established may differ depending on who initiates the shared focus. It can either be parent-led, which occurs when the parent directs the child's gaze to a target point of reference (known as Responding to JA), or conversely child-led, which is when the child directs the parent to a target point of reference (known as Initiating JA; Mundy et al., 2007). This distinction could provide valuable insights into the quality of the interaction, as initiation JA and responding to JA may serve different function during this shared state of attention. Specifically, Mundy and colleagues (2007) argue that initiating JA involves more intentional control of social attention which may provide

children with learning opportunities that are less available through a more reflexive process like responding to JA. As such, how parents respond to children's intentional attempts to direct shared attention may be important, as following the child's attentional gaze may provide opportunities for parents to provide support and extend their child's engagement.

Since JA fundamentally involves the coordination of visual attention towards a common point of reference, measuring where and when each interaction partner is looking over time is essential to understanding how JA unfolds during an interaction. Accordingly, because JA is a dynamic process that unfolds through moment-to-moment gaze coordination, understanding how it operates during those problem-solving spaces requires examining real-time gaze patterns between individuals.

Eye Tracking Method

To examine coordination of attention between individuals, researchers can use eye-tracking devices to capture attentional gaze instead of the traditional third-party manual coding of looking behaviour (Ambrose et al., 2021; Schroer et al., 2024; Yu & Smith, 2017). Eye-tracking technology provides a continuous measure of where individuals direct their visual attention during an interaction (Schroer et al., 2024). This allows researchers to understand how interactive partners coordinate their attention and respond to each other in a naturalistic setting.

Eye-tracking methods have been used extensively to understand how JA supports learning and attention regulation. For instance, Yu and Smith (2016) conducted a study where they had both parents and infants wear a head-mounted eye tracker while they engaged in toy play to examine how the parent's and infant's attentional coordination and social context impacted their sustained attention. Their findings showed that infants sustained attention to the target object longer when they observed that parents joined them in attending to the same object

as well (Yu & Smith, 2016). The authors argue that this form of JA is a precursor for sustained attention and self-regulation of attention which is said to have social origins instead of being an innate feature (Yu & Smith, 2016). However, it is less clear what specific parenting behaviours such as manual actions or speech support joint and sustained attention, a gap this work aims to address. In a similar context, Schroer and colleagues (2024) conducted a study where they had the parent and toddler wear mobile eye trackers in their home to investigate the real-time dyadic patterns of their visual attention and actions in everyday routines. They found that a child's attention to the named target object increases when parents also coordinate their attention to that object while simultaneously holding it. This demonstrates the importance of JA and coordinated actions in word learning environments. Together these studies suggest that JA is a vital precursor through which parents can influence children's attention and learning in real-time.

Because past research has viewed JA as a foundational milestone for early language acquisition and social communication (Bakeman & Adamson, 1984), this existing eye-tracking literature has mainly focused on infants and toddlers, as in the studies mentioned above. Therefore, much less is known about how JA functions in later developmental periods, where children are expected to transition away from basic object play and engage in more autonomous decision-making and problem-solving (Grolnick et al., 2002).

While early developmental research focuses heavily on how JA operates in unstructured play, there is a separate body of work that examines how it becomes critical when older children collaborate on goal-directed tasks. For example, MacNeill and colleagues (2022) investigated the co-occurrence of 5- to 7-year-old children's visual attention and parental behaviours (i.e., positive reinforcement, teaching, etc.) while completing three tangram puzzles in six minutes. They found that children's visual attention co-occurred with directive and intrusive parental

behaviors, suggesting that parental control may be closely linked to children's attentional patterns during the task. These findings demonstrate how children's visual attention can provide insight into how they engage with and respond to parental support during problem solving tasks. However, because only the child wore the eye-tracker device, they were unable to capture the bidirectional nature of JA, leaving it unclear how real-time JA drives collaborative behaviours of both partners in a goal-oriented task.

PRESENT STUDY

The overarching aim of the present study is to investigate how parental motivational state impacts dyadic JA and parental behaviour during a challenging parent-child task, and how these factors relate to the child's problem-solving performance. This study aims to address the above-mentioned literature gaps by utilizing a dual mobile eye-tracking method to capture the visual attention of both the parent and child. Moreover, this design used a structured, goal-directed puzzle building task because it mimics a naturalistic learning context common to daily life, while providing an inherently collaborative and developmentally appropriate challenge for testing children within the targeted age range.

More specifically, the first objective of this study is to examine how parents' manipulated motivational state impacted the overall proportion and type of JA (parent-led vs child-led) the dyads engaged in. Parents' motivational state was manipulated by having the parents randomly assigned to one of two experimental conditions designed to alter their motivation right before the task: a process-oriented condition (emphasizing the child's independent learning experience, enjoyment and autonomy supportive guidance) or an outcome-oriented condition (emphasizing successful puzzle completion within the 8-minute time limit). This experimental design allows for the evaluation of whether parental motivational goals actively shape how JA is established, especially when distinguishing between parent-led and child-led JA patterns. The second objective of this study is to explore whether the overall proportion of JA instances and type of JA predict children's puzzle completion accuracy. Finally, the third objective is to explore whether parental behaviours could be associated with the quantity and type of JA dyads engage in depending on the condition they are in. To address this aim, parental behaviour was evaluated using previously established event-based codes that were categorized into two distinct

dimensions: autonomy-promoting behaviours (e.g., scaffolding, encouragement) or controlling behaviours (e.g., directives, intrusion).

I hypothesized that there would be more overall JA in the process-oriented condition compared to the outcome-oriented condition. I anticipated that there would be more child-led JA in the process-oriented condition compared to the outcome-oriented condition and more parent-led JA in the outcome-oriented condition. I also hypothesized that higher overall proportions of JA, and particularly child-led JA, would be associated with greater accuracy in children's puzzle completion. Moreover, I hypothesized that the manipulated motivational state would be associated with specific parental behaviour which in turn would be associated with JA type and amount. Specifically, autonomy promoting behaviours were hypothesized to positively correlate with overall amount of JA and more specifically the child-led JA frequency. Conversely, more controlling behaviours were not expected to be associated with overall JA but instead with parent-led JA.

METHOD

Participants

A total of 102 parent-child dyads with children between the ages of 4-5 years ($M_{age(months)}$ = 58.76, *SD* = 15.60) participated in a larger study examining parent and child behaviours during a Parent–Child Collaborative Task (PCCT). Following this task, children independently completed two transfer tasks (one near and one far) designed to assess the effects of parenting behaviours and JA on children's independent problem-solving skills, persistence, and success in the subsequent tasks. However, due to technical malfunctions resulting in data loss, useable eye-tracking data were available for only 29 dyads. As the present thesis focuses specifically on the eye-tracking component of the study, the final sample size will consist of 29 parent-child dyads (Child: $M_{age(months)}$ = 57.93, *SD* = 7.47, *N* = 29, 62.1% males, 37.9% females; Parent: $M_{age(years)}$ = 36.69, *SD* = 3.62, *N* = 29, 13.8% males, 86.2% females). This sample size aligns with typical eye-tracking studies with children, which often include approximately 20–30 participants or dyads (i.e., Franchak et al., 2018; Yu & Smith, 2016; Bakeman & Adamson, 1984).

Parents identified 89.7% of children as White in ethnicity and 10.3% as other (i.e., White/West Indian, Metis, Chinese/White). All participating parents were the child's biological parent and self-identified as the following ethnicities; 92.9 % as White, 3.6% as Chinese and 3.6% as other. The majority of the participating parents were highly educated, with 27.6% being graduate school graduates, 65.5% being college graduates, 3.4% partially college trained or CEGEP, and 3.4% secondary school graduates.

This research study received ethics clearance from the University of Waterloo's Research Ethics Board (ORE# 44942). Participants were recruited via email from the Social Development Lab and Developmental Learning Lab participant databases.

Procedure

Participants were recruited in the Waterloo region via email from the Social Development Lab and Developmental Learning Lab participant databases. Interested families completed a screening questionnaire to assess their eligibility. To participate, parents and children were required to be English speakers to ensure task comprehension and allow for accurate speech coding by research assistants. Children with diagnosed developmental delays were not included, and participants with vision-related problems, such as an inability to remove eyeglasses to complete the task (because eye-trackers did not allow glasses) or colour blindness, were not included. Parents filled out a series of questionnaires on family demographics, their child's typical behaviours and their own parenting behaviours alongside their consent on Qualtrics. Parents and children participated in a one-hour session with a researcher in a quiet room (see Appendix A for Study Protocol).

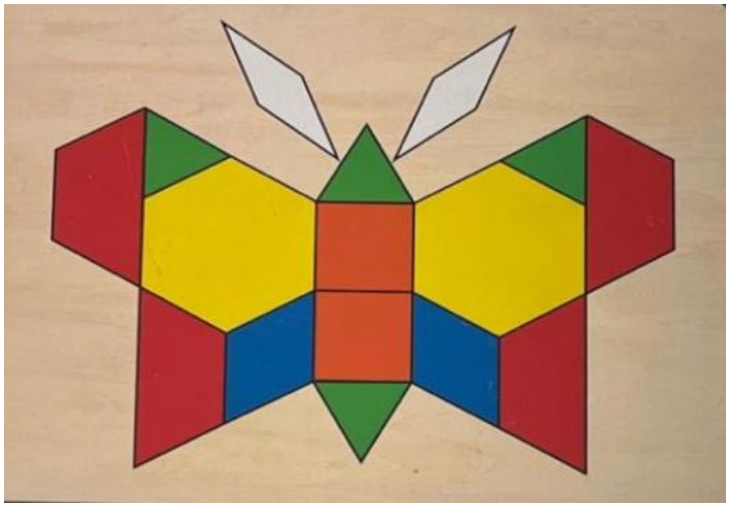
The parent and child completed a modified version of the Parent-Child Challenge Task (PCCT: Lunkenheimer et al., 2017) and two subsequent tasks that were not examined for the thesis.

***Parent-Child Challenge Task (Tangram Puzzle)*:** Each parent and child dyad were seated side by side at a table with a large (empty) whiteboard and two smaller whiteboards on adjacent sides (the parent's board and the child's board) with magnetic wooden puzzle pieces varying in shape and colour. They were both fitted with head-mounted eye-tracking glasses that recorded their gaze patterns throughout their interaction. A ceiling-mounted camera recorded their interaction from a third point of view to capture parental behaviours. Each dyad was asked to collaboratively recreate three tangram puzzles of increasing difficulty within an eight-minute period (see Figure 1 for an example). In the present task, the three target figures increased in

complexity. The wooden pieces required to construct each target design were evenly divided between the two smaller whiteboards, such that neither partner had access to all necessary pieces. This arrangement ensured coordination and communication between the parent and child to complete each puzzle. The puzzles were intentionally designed to be challenging for children in this age range, such that children required some extent of parental guidance to complete them (McNeill et al., 2022).

Figure 1

Image of Second Tangram Puzzle: The Bird



This study was a between-subjects design where dyads were randomly assigned to either a process-oriented condition or an outcome-oriented condition. Prior to beginning the task, parents in both conditions were instructed that their child would be tasked to complete three puzzles within eight minutes. They were allowed to provide verbal help but were not allowed to physically help, except when asked to pass pieces from their own pile at their child's request. Following these instructions, parents received a condition-specific written prompt. In the process-oriented condition, parents were instructed that "The MOST important thing is to focus

on your child's learning experience. Try to enjoy the process and guide and support your child as they work through the puzzle." In the outcome-oriented condition, parents were instructed that "The MOST important thing is to focus on getting the puzzles done. For us to get ALL the information we need, it's REALLY important that your child completes the 3 puzzles." The process-orientation condition was intended to emphasize children's learning experience, enjoyment and parental guidance, whereas the outcome-oriented condition emphasized the completion of the puzzle within the eight-minute mark. These condition-specific instructions were designed to experimentally manipulate parents' motivational state and examine its impact on parent-child interactive behavioural patterns during the PCCT.

Coding of JA using Eye-Tracking

Apparatus. The eye trackers used in this study were the child and adult UltraFlex Eye Tracking Headgear by Positive Science. It consists of an outward facing "scene" camera that records a first-person perspective of the participant's visual field and an inward facing infrared camera that records their right pupil. Both videos were captured simultaneously using Positive Science Live Capture software. These two videos were then synced with nine-point calibration through the Yarbus eye-tracking software to ensure accurate gaze mapping resulting in a composite video with a superimposed crosshair indicating the participant's point of gaze.

Coding Region of Interests. The calibrated eye tracking video and scene video was then uploaded into GazeTag, a coding software by Positive Science which automatically identifies fixation events. Fixations were defined as instances in which gaze remains in one location for longer than 100ms (Bianchi et al., 2020). For each fixation, GazeTag extracted the corresponding scene frame with the crosshair overlaid to indicate gaze position. This allowed for frame-by-frame coding of fixations according to eight predefined regions of interests (ROIs). These ROIs

included the *Big Board*, defined as the main board on which the target puzzle was recreated; the *Example Board*, the smaller board displaying the printed target image; the *Parent's Board*, the smaller board positioned adjacent to the main board on the parent's side; and the *Child's Board*, the small board positioned adjacent to the main board on the child's side. The remaining four ROIs are related to gaze direction towards the interaction partner and included the *Child's Head*, *Child's Hands*, *Parent's Head*, and *Parent's Hands*. Once all fixations were coded, an excel output file was produced for each participant that included fixation onset time, offset time, coded ROI, etc. In total, there were 58 output files (29 parents and 29 children) produced to be analyzed. To assess coding reliability, 18 of the 58 participants (30%) were independently coded by a trained research assistant who was blind to the hypotheses of the study. Agreement between the primary coder and reliability coder was 87.9% and Cohen's Kappa was .85, indicating high reliability.

Coding of JA. Joint attention was computed using a Python code developed by an external programmer. The code first synchronized the parent and child fixation datasets based on the onset of the first puzzle placement on the *Big Board* to ensure alignment across the dyad. Following prior eye-tracking studies, joint attention was operationally defined as instances in which both members in a dyad simultaneously fixated on the same region of interest for a minimum duration of 500ms (Yu & Smith, 2013; 2016; Schroer et al., 2024). The two datasets were then merged to identify these temporal overlaps in fixations with matching ROIs.

Using these established instances of JA, several JA variables were computed. *Total JA Instances* were calculated as the total number of overlapping fixations between the parent and child that met the minimum JA duration criterion of 500ms. *Total Duration of JA* was calculated as the cumulative duration (in seconds) of all established JA instances. Because dyads differed in

the number of puzzles completed, proportion scores were also computed and used instead. *Proportion of JA Instances* was calculated by multiplying the total number of established instances of JA by two and dividing by the combined total number of fixations from the parent and child. *Proportion of Joint Attention Duration* was calculated by dividing the cumulative duration of JA by the total duration of the task. This accounts for differences in the amount of time dyads spent for completing each puzzle.

Coding of JA Initiation Type. JA instances were categorized based on initiation type: parent-led or child-led. Trained coders reviewed the parent and child eye-tracking output files to identify whether the parent or child initiated each instance of JA. For each overlapping event, coders matched the overlap start time to the corresponding fixation in the parent and child output dataset and identified the initiation based on which partner's fixation began first. Joint attention instances were coded as parent-led when the parent's fixation preceded the child's fixation and child-led when the child's fixation preceded the parent's fixation.

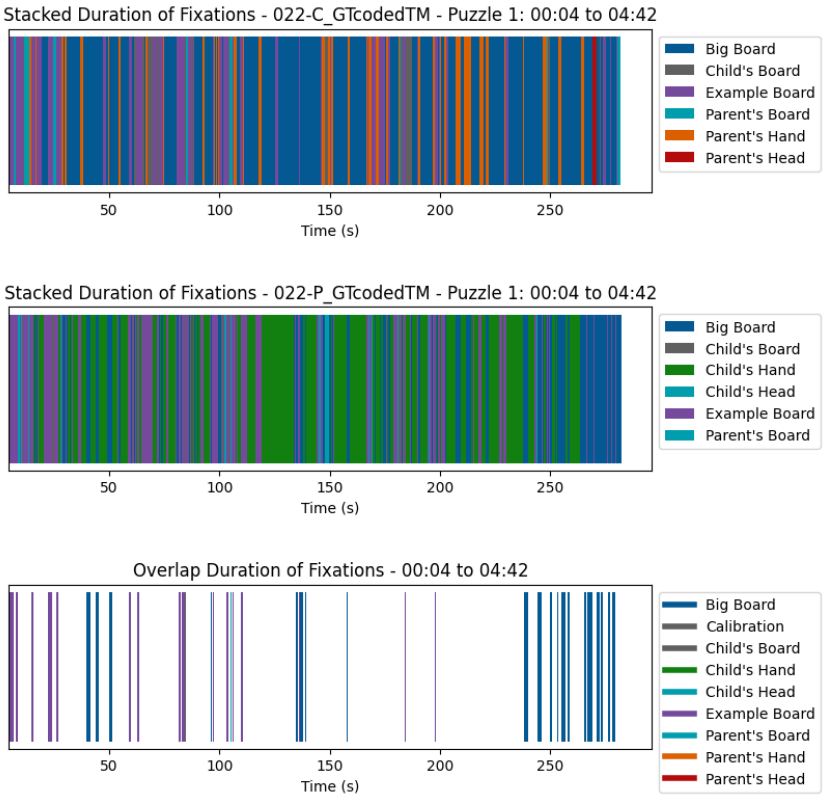
To verify coding accuracy, an R script was developed by one of the coders to automatically determine initiation type using the same coding criteria as the manual coding scheme. The script then compared the automated JA initiation type classifications with the manually coded classifications to ensure that both coding approaches yielded the same initiation type classification. Agreement between the two coding methods was 100%, and thus, additional reliability analyses were not conducted for JA initiation type.

To summarize, *Parent-Led Instances of JA* were calculated as the number of JA instances initiated by the parent, whereas the *Child-Led Instances of JA* were calculated as the number of JA instances initiated by the child.

Visualization of Gaze Patterns. Since each participant's GazeTag outputs consisted of a large spreadsheet containing all their individually coded fixations, the raw data were difficult to interpret. The same Python code was used to convert those numerical fixations into visual timeline plots displayed as stacked horizontal bar graphs. These plots showcased which regions of interest each participant was looking at from the start to the end of the task. As shown in Figure 2, three timeline plots were generated: one for the child's gaze allocation, one for the parent's gaze allocation, and a third displaying only the overlapping fixations, which were operationalized as instances of JA. See Appendix B for all individual dyad visualizations.

Figure 2

Eye-Tracking Visualization of Dyad 022 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Accuracy of Tangram Puzzle Task. Children's performance was measured using accuracy scores coded for each of the three puzzles reconstructed on the *Big Board*. Each puzzle consisted of a fixed number of pieces that differed in shapes and color; puzzles differed in the number of pieces. For example, Puzzle 1 involved reconstructing a Bird using 10 pieces in total: two orange squares, one yellow hexagon, one red trapezoid, four white parallelograms, one green triangle and one blue parallelogram. For each puzzle, the accuracy score was defined as a proportion of total number pieces correctly placed out of the total number of possible pieces. A piece was considered correctly placed if it was correctly positioned in the right location and orientation. Higher scores reflected greater task accuracy and success on the PCCT. The accuracy variable was computed as an average across the three puzzle scores.

Coding of Parenting Behaviour. Parents' verbal communication behaviours were event-coded by previous researchers using Mangold Interact Software (Ghanem, 2024). The coding scheme was based on previous literature on parent-child interactions (Diercks et al., 2021; Eyberg et al., 2014; Lunkenheimer, 2009; Lunkenheimer et al., 2017). See Table 1 for full list of codes with associated description and examples. These codes were categorized as either autonomy-promoting (e.g., scaffolding, encouragement, positive reinforcement) or controlling (e.g., directives, intrusion).

Table 1

Description of Parenting Behaviour Codes

Code	***Description***	***Example***
	Autonomy-Supporting	
Positive Reinforcement	Parent offers praise or supportive acknowledgment of child	"Good job!" "You're doing so well"
Proactive Structure	Parent guides or prompts the child to promote success on the task by providing choices or making a game of a task to keep the child engaged	"Do you want to start with the blue or yellow piece?" "Let's see how fast we can do this one"
Teaching	Explanations or open-ended questions that promote the child's learning and problem-solving	"Where should this piece go?" "What's the best piece we could start with?"
	Controlling	
Direct Command	Instructions or commands that do not allow the child to make a choice or practice independence and autonomy	"Put the green piece there" "Look at the picture" "Flip it"
Indirect Command	A suggestion that is implied or stated in question form for the child or phrases that imply that compliance is not a necessity	"I think you need to move the yellow piece closer" "Can you put the red one on top?" "I'd like you to finish this"
	Other	
Emotional Validation	Validating the child's emotional point of view or directly labelling the child's emotion	"This part is hard, right?" "I can see that you're upset"
Neutral Talk	Statements or brief verbal response to the child that contains no real content and that do not clearly describe or evaluate the child's behaviour.	"Here you go" "Sure" "You have these at home"
Negative Talk	Verbal expression of disapproval of the child or the child's behaviours, activities, or choices	"No" "That's not right" "This is all wrong"

RESULTS

SPSS statistics (developed by IBM) was used to conduct analyses including t-tests, repeated measure ANOVAs, correlations and regressions. During the preliminary analysis, the descriptive statistics revealed that all variables fell within the recommended range for skew and kurtosis (skew|≤3; |kurtosis|≤10) (Kline, 1998). No datapoints were excluded due to outlier analyses.

Table 2

Descriptive statistics for core study variables

	N	*M*	*SD*	*Min.*	*Max.*
Total JA Instances	29	73.72	22.95	33.00	120.00
Proportion of JA Instances	29	0.23	0.073	0.11	0.45
Total Duration of JA (sec)	29	82.20	35.55	31.28	186.44
Proportion of Joint Attention Duration	29	0.15	0.062	0.08	0.34
Parent-Led Instances of JA (Count)	29	23.17	12.30	5.00	53.00
Child-Led Instances of JA (Count)	29	50.55	15.29	26.00	83.00
Accuracy of Puzzles (%)	29	71.18	31.57	0.00	100.00

Main Analysis

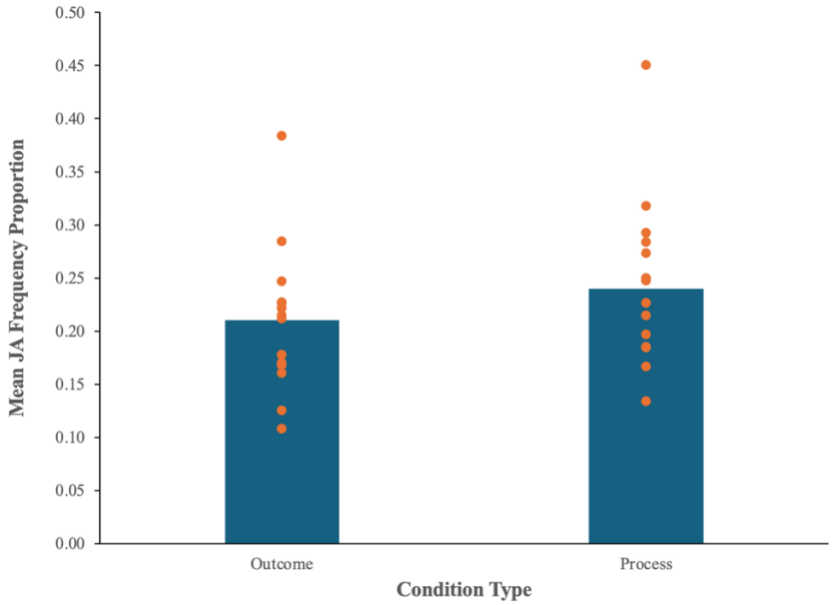
Joint Attention and Condition

To address my first research objective of whether proportion and type of JA differed by condition, an independent t-test and repeated measures ANOVA, respectively, were conducted.

Proportion of JA. The independent t-test revealed that overall proportion of JA did not significantly differ by condition (Process-Oriented: $M = 0.24$, $SD = 0.02$, $N = 15$; Outcome-Oriented: $M = 0.21$, $SD = 0.07$, $N = 14$; $t\ (27) = 1.29$, $p = .208$; see Figure 3).

Figure 3

Proportion of Joint Attention by Condition (Process vs. Outcome)

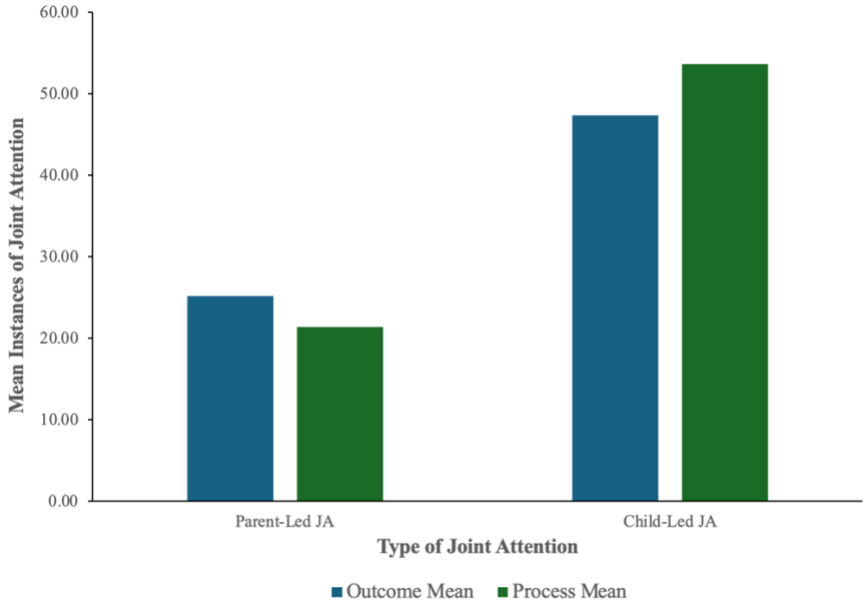


Note. Orange dots represent raw individual data points.

Type of JA. For the 2 x 2 mixed-measure ANOVA, process-oriented and outcome-oriented condition was the between-subject factor and the parent-led and child-led was the within-subject factor. The analysis revealed that there was significantly more child-led than parent-led JA, F (1, 27) = 95.35, $p < .001$ (see Figure 4). However, there was no significant main effect of condition, F (1, 27) = 0.08, $p = .775$, nor was there a significant interaction between JA type and condition, F (1, 27) = 3.30, $p = .080$, indicating that the difference between child-led and parent-led JA did not vary between the process-oriented and outcome-oriented conditions.

Figure 4

Joint Attention Type by Condition (Process vs. Outcome)



Joint Attention and Child's Performance (i.e., Accuracy)

To address my second research objective on whether overall proportion and type of JA predict child's puzzle completion accuracy (M = 71.18, SD = 31.57), a linear regression was conducted.

Proportion of JA. The linear regression revealed that the model was not significant, F (1, 27) = 0.043, p = .837, with an R^2 of .002, indicating that proportion of JA did not significantly predict children's puzzle accuracy.

Type of JA. The linear regression revealed that the model was not significant, F (2, 26) = 0.77, p = .475, with an R^2 of .056, indicating that neither parent-led nor child-led JA significantly predict children's puzzle accuracy.

Parent Behaviours and Joint Attention

The final research objective was whether specific parental behaviours were associated with the overall proportion and type of JA between conditions. However, because the earlier

analyses revealed that there were no significant differences in overall proportion and type of JA between the two conditions, the planned regression analysis not pursued. Instead, bivariate correlation analyses were conducted to explore the potential associations between parental behaviours and all JA variables, which ultimately revealed no significant correlations between these variables as shown in Table 3.

Table 3

Correlations between joint attention and parenting behaviour variables

	Autonomy-Supporting			Controlling		Other		
	Positive Reinforcement	Proactive Structure	Teaching	Direct Command	Indirect Command	Emotional Validation	Neutral Talk	Negative Talk
JA Duration Proportion	.002	.334	.095	-.176	-.162	.273	.250	-.221
JA Frequency Proportion	-.149	.370	.038	-.265	-.126	.216	.098	-.226
Parent-Led JA (Count)	-.030	.272	.092	-.091	-.226	.167	-.087	-.059
Child-Led JA (Count)	.045	.133	-.143	-.140	-.155	-.002	.182	-.011

Note. ** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Exploratory Analysis on JA split by puzzle

Given that the three puzzles varied in visual complexity and task demands, an exploratory analysis using a set of Mixed Linear Models was conducted to examine whether JA variables differed across the three puzzles. In the Mixed Linear Models, puzzle number (i.e., Puzzle 1, Puzzle 2, and Puzzle 3) and condition (i.e., process-oriented and outcome-oriented) were entered as fixed effects, with puzzle number representing the within-dyad factor and condition representing the between-dyad factor. Dyad ID was included as a random effect to account for repeated observations.

Total JA Instances. The linear mixed model revealed that total JA instances significantly differed across puzzles, F (2, 26.04) = 5.57, p = .010. Follow-up Bonferroni-corrected pairwise comparisons found that this effect was primarily driven by a significant difference between Puzzle 1 and Puzzle 2, with dyads demonstrating more total JA instances during Puzzle 1 (M = 40.79, SE = 3.28) compared to Puzzle 2 (M = 27.43, SE = 3.66), p = .009. No significant differences were observed between Puzzle 1 and Puzzle 3 (M = 32.04, SE = 4.55), p = .250 nor between Puzzle 2 and Puzzle 3 (p = 1.00).

Total Duration of JA. The linear mixed model revealed that total duration of JA (seconds) significantly differed across puzzles, F (2, 24.61) = 4.03, p = .031. Follow-up Bonferroni-corrected pairwise comparisons found that this effect was primarily driven by a significant difference between Puzzle 1 and Puzzle 2, with dyads demonstrating more total duration of JA during Puzzle 1 (M = 46.32, SE = 4.87) compared to Puzzle 2 (M = 30.99, SE = 5.37), p = .028. No significant differences were observed between Puzzle 1 and Puzzle 3 (M = 37.26, SE = 6.50), p = .535 nor between Puzzle 2 and Puzzle 3 (p = 1.00).

Proportion of JA Instances. The linear mixed model revealed that proportion of JA instances significantly differed across puzzles, F (2, 26.08) = 5.32, p = .012. Follow-up Bonferroni-corrected pairwise comparisons found that this effect was primarily driven by a significant difference between Puzzle 1 and Puzzle 2, with dyads demonstrating more proportion of JA instances during Puzzle 1 (M = 0.13, SE = .014) compared to Puzzle 2 (M = 0.09, SE = .015), p = .010. No significant differences were observed between Puzzle 1 and Puzzle 3 (M = 0.11, SE = .017), p = .348 nor between Puzzle 2 and Puzzle 3 (p = .932).

Proportion of JA Duration. The linear mixed model revealed that proportion of JA duration did not significantly differ across puzzles, F (2, 36.79) = 0.79, p = .460.

Parent-Led Instances of JA. The linear mixed model revealed that parent-led instances of JA significantly differed across puzzles, F (2, 26.11) = 7.31, p = .003. Follow-up Bonferroni-corrected pairwise comparisons found that this effect was primarily driven by a significant difference between Puzzle 1 and Puzzle 2, with dyads demonstrating more parent-led instances of JA during Puzzle 1 (M = 14.15, SE = 1.55) compared to Puzzle 2 (M = 8.23, SE = 1.69), p = .0.003. No significant differences were observed between Puzzle 1 and Puzzle 3 (M = 9.96, SE = 2.01), p = .112 nor between Puzzle 2 and Puzzle 3 (p = 1.00).

Child-Led Instances of JA. The linear mixed model revealed that child-led instances of JA significantly differed across puzzles, F (2, 29.91) = 3.36, p = .048. Follow-up Bonferroni-corrected pairwise comparisons found that this effect was primarily driven by a significant difference between Puzzle 1 and Puzzle 2, with dyads demonstrating more child-led instances of JA during Puzzle 1 (M = 26.65, SE = 2.19) compared to Puzzle 2 (M = 19.04, SE = 2.47), p = .051. No significant differences were observed between Puzzle 1 and Puzzle 3 (M = 21.46, SE = 3.13), p = .466 nor between Puzzle 2 and Puzzle 3 (p = 1.00).

Puzzle Accuracy. The linear mixed model revealed that puzzle accuracy (percentage) did not differ significantly across puzzles, F (2, 28.68) = 0.200, p = .820.

DISCUSSION

Parents are highly invested in knowing how to support their children better and provide them with high-quality learning experiences. One focus within this area is understanding how parents can build their child's autonomy through scaffolding, as it allows them to develop the independent problem-solving skills needed to navigate challenges on their own. This process can be facilitated through JA as it helps parents be aligned with their child's needs to know when to offer support and when to step back. A promising tool for capturing how parents are visually behaving during scaffolding is by utilizing dual mobile eye-tracking devices to map real-time shared gaze patterns of the dyad. Within this general area of research, this thesis sought to investigate the bidirectional patterns of parent-child joint attention (JA) in relation to parental motivational states, parental behaviours and children's task performance.

My first research objective sought to understand whether parents manipulated motivational states (process-oriented vs. outcome-oriented) affected the overall proportion and initiation type (child-led or parent-led) of JA in the dyad. I hypothesized that there would be more overall instances of JA and a greater frequency of child-led JA in the process-oriented condition. However, contrary to my hypothesis, there were no significant differences in overall instances of JA nor type of JA between the two conditions, indicating the experimental manipulation had very little impact on the dyad's visual coordination. These findings contrast with previous work that suggests process-oriented motivational states promote autonomy supportive behaviours while an outcome-orientation increases controlling parenting behaviour (Grolnick et al., 2002; Wuyts et al., 2017). One explanation could be that the collaborative nature of the tangram puzzle task may have constrained the differences between conditions. Because neither partner possessed all the puzzle pieces required, successfully solving the puzzle required continuous visual coordination regardless of the motivational framing. Thus, the two

experimental conditions may have yielded similar patterns of visual attention simply due to task demands. Another possibility is that the motivational manipulation could have influenced parents' verbal communication instead. Analysis on the coded parent behaviors did reveal that motivational manipulation was effective such that in the process-oriented condition, parent displayed an increase in overall autonomy-supportive behaviors (Ghanem, 2025). Although parents may have altered their content or tone of guidance in response to the manipulation, these changes may not have impacted where they directed their gaze.

While the experimental manipulation did not alter visual coordination, a main effect of JA type did emerge such that, across both conditions, children initiated more JA than parents did. This finding suggests that the visual coordination between a parent and child may be resilient to the point that it is not easily disrupted by experimental manipulations. While this might seem unexpected given that performance pressure often pushes parents towards more controlling behaviours, it highlights that fundamentally the interaction remains child driven. This aligns well with the theory that frames children as active agents who volitionally initiate coordination of attention to satisfy their own innate psychological needs for autonomy and competence (Grolnick, 2009; Lerner et al., 2022). While traditionally scaffolding emphasizes parents as the primary guide who leads the learning interactions, as children grow older the dynamic changes (Hustedt & Raver, 2002). As such, by leading JA, children are actively guiding the collaborative exchange, showcasing that ultimately, the interaction remains dependent on the child's agency even when parents face pressure to complete the task successfully. Perhaps children in our sample were particularly confident in their puzzle solving skills and did not feel compelled to follow their parents' lead, even initially.

My second research objective was to explore whether the overall proportion and type of JA predicted puzzle completion accuracy. I originally hypothesized that higher overall proportion of JA and child-led JA would predict greater accuracy in the puzzle completion. However, the results did not reflect this and instead may contrast with Barron's (2003) finding that more joint engagement leads to better collaboration. One possible explanation is that the difficulty of the tangram puzzles could have changed what the JA actually meant throughout the task. It could be the case that the instances of JA may not reflect a learning process but instead moments of shared struggle as the dyads navigate the difficult task, or moments of happiness when a piece was successfully placed. Moreover, successful performance on the tangram puzzles likely depends on other cognitive processes (i.e., executive functioning, working memory) that extend beyond the benefits of shared visual attention. This suggests that while JA may facilitate coordination between parents and children to share knowledge, it may not directly translate to improved task accuracy during this task.

The final research objective intended to investigate whether specific parenting behaviours, such as positive reinforcement or direct command, served as a mechanism that linked the manipulated motivational state with JA. I hypothesized that the manipulated motivational state would influence parents' use of autonomy-promoting behaviours, which in turn would be associated with differences in JA. Specifically, autonomy-promoting behaviours would be associated with child-led JA, while controlling behaviours would be associated with parent-led JA. Interestingly, no significant correlations were found between any of the coded parental behaviours and any JA variables. This could suggest that scaffolding behaviour and shared visual attention may operate as independent methods of support instead. For example, a parent may be giving verbal praise or direct command while looking somewhere else, or a dyad

may be coordinating attention in instances where guidance is not even taking place. In addition, one concern could be the analysis utilized, as it does not take into consideration that specific parental behaviours may influence JA in the first few seconds of the event rather than across the interaction. As such, future work should examine parental behaviour in connection to JA while taking temporal sequence into account.

Despite the absence of significant findings for the primary analyses, the exploratory analyses offered further insight into how JA changed throughout the interaction. Specifically, it was revealed that dyads demonstrated significantly more instances, and differences in type and duration of JA during the first puzzle compared to the second puzzle. Interestingly, children's puzzle accuracy remained stable across all three puzzles. One possible explanation for this is that dyads required greater visual coordination in the beginning of the task so that a shared understanding of the task demands could be established along with possible strategies. As they became more familiar with the puzzle task and approaches to solve it, less visual coordination may be required to maintain the collaboration with the parent. The absence of differences in puzzle accuracy further supports these interpretations, such that even with reduced JA, collaborative efficiency remained the same supporting successful task completion. It is also curious that there were no differences between the 1st and 3rd puzzles for these exploratory analyses, though this might be due to reduced power for examining puzzle three since only some dyads completed it. Collectively, these findings reinforce the importance of understanding when JA occurs during collaborative task instead of how much JA occurs.

LIMITATION AND FUTURE DIRECTIONS

Despite the valuable insights this study provides into how preschoolers and parents coordinate their attention during a problem-solving task; several limitations should be considered when interpreting the findings of this thesis.

One important limitation to note is the final sample size of this study. Although the initial sample size included 102 parent-child dyads, technical malfunctions during data storage of the eye tracking data resulted in usable eye-tracking data for only 29 dyads. While this sample size is consistent with previous developmental eye-tracking research, the data loss likely reduced the statistical power to detect meaningful effects, particularly for the condition comparisons of JA, parenting behaviours and puzzle performance. As such, the non-significant findings may reflect limited statistical power rather than the absence of a meaningful effect.

A second limitation is that the present study did not account for the temporal sequence of parenting behaviours relative to JA. Because parenting behaviours was coded as a frequency count, it overlooked the dynamic nature of when and where parenting behaviours may influence shared visual coordination. As such, examining the temporal relationship between parenting behaviours and JA may provide a better understanding of which parental behaviours are most effective in establishing JA.

A third limitation is the possible misclassification of parent led and child led JA. In the present study, instances of JA were classified as child-led when the child had looked at the target before the parent and vice versa. However, the temporal order of gaze may not necessarily indicate who directed the other's attention. It could be the case that a parent may simply look at an object first, with the child following their gaze, without the parent actively directing the child's attention to begin with. Determining whether an instance of JA was truly parent or child-led may require more fine-grained consideration of additional factors, such as verbal

communication or gestures. Thus, by examining the verbal communication alongside the JA initiation codes may provide a more comprehensive understanding of the interaction and allow for a more accurate determination of who directed the other's attention.

The final limitation is in regard to the experimental manipulation of parental motivation state. Although parents received a written prompt to alter their motivational state that emphasized either a process-oriented or outcome-oriented goal, it may not have been sufficient to override parents already established interactive styles during the task itself. As a result, the absence of condition differences may reflect the influence of parenting styles instead of the experimental manipulation. Future research should use more intensive or sustained manipulations, such as repeated prompts or more immersive instructions throughout the task, to ensure that parents' motivational state was successfully altered.

CONCLUSION

In conclusion, the present study examined how parental motivational state, parenting behaviours and JA relate to parent-child collaboration during a problem-solving task. Although there was no impact of parental motivational state on JA, nor did JA predict child's puzzle completion accuracy, children led more JA than parents regardless of condition. Moreover, exploratory analyses suggested that dyads engaged in more JA during the initial stages of the task, portraying the changing role of coordinated visual attention throughout the task. Together, these findings contribute to the growing literature on JA by demonstrating the importance of examining the bidirectional nature of parent-child interaction in a naturalistic learning context. This acts as a building block for future research on how parents can better support children's developing autonomous learning abilities.

REFERENCES

Ambrose, D., MacKenzie, D. E., Ghanouni, P., & Neyedli, H. F. (2021). Investigating joint attention in a guided interaction between a child with ASD and therapists: A pilot eye-tracking study. *The British Journal of Occupational Therapy*, *84*(10), Article 0308022620963727. https://doi.org/10.1177/0308022620963727

Bakeman, R., & Adamson, L. B. (1984). Coordinating Attention to People and Objects in Mother-Infant and Peer-Infant Interaction. Child Development, 55(4), 1278–1289. https://doi.org/10.2307/1129997

Barron, B. (2003). When Smart Groups Fail. *The Journal of the Learning Sciences*, *12*(3), 307–359. https://doi.org/10.1207/S15327809JLS1203_1

Bianchi, L. J., Kingstone, A., & Risko, E. F. (2020). The role of cognitive load in modulating social looking: a mobile eye tracking study. *Cognitive Research: Principles and Implications*, *5*(1), Article 44. https://doi.org/10.1186/s41235-020-00242-5

Bindman, S. W., Pomerantz, E. M., & Roisman, G. I. (2015). Do Children's Executive Functions Account for Associations Between Early Autonomy-Supportive Parenting and Achievement Through High School? *Journal of Educational Psychology*, *107*(3), 756–770. https://doi.org/10.1037/edu0000017

Bradley, H., Smith, B. A., & Wilson, R. B. (2023). Qualitative and quantitative measures of joint attention development in the first year of life: A scoping review. *Infant and Child Development*, *32*(4). https://doi.org/10.1002/icd.2422

Butterworth, G., & Jarrett, N. (1991). What minds have in common is space: Spatial mechanisms serving joint visual attention in infancy. *British Journal of Developmental Psychology*, *9*(1), 55–72. https://doi.org/10.1111/j.2044-835X.1991.tb00862.x

Carr, A., & Pike, A. (2012). Maternal Scaffolding Behavior: Links With Parenting Style and Maternal Education. *Developmental Psychology*, *48*(2), 543–551. https://doi.org/10.1037/a0025888

Chen, C., Castellanos, I., Yu, C., & Houston, D. M. (2020). What leads to coordinated attention in parent–toddler interactions? Children's hearing status matters. *Developmental Science*, *23*(3), e12919-n/a. https://doi.org/10.1111/desc.12919

Conner, D. B., Knight, D. K., & Cross, D. R. (1997). Mothers' and fathers' scaffolding of their 2-year-olds during problem-solving and literacy interactions. *British Journal of Developmental Psychology*, *15*(3), 323–338. https://doi.org/10.1111/j.2044-835X.1997.tb00524.x

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. Plenum Press. https://doi.org/10.1007/978-1-4899-2271-7

Diercks, C. M., Lunkenheimer, E., & Brown, K. M. (2021). The dynamics of maternal scaffolding vary by cumulative risk status. *Journal of Family Psychology, 35*(2), 203.

Eyberg, S. M., Chase, R. M., Fernandez, M. A., & Nelson, M. M. (2014). *Dyadic parent-child interaction coding system (DPICS) clinical manual (*4th ed.). PCIT International.

Fogel, A. (1993). Two principles of communication: Co-regulation and framing. In J. Nadel & L. Camaioni (Eds.), *New perspectives in early communicative development* (pp. 9–22). New York: Routledge. https://doi.org/10.4324/9781315111322-3

Franchak, J. M., Kretch, K. S., & Adolph, K. E. (2018). See and be seen: Infant–caregiver social looking during locomotor free play. *Developmental Science*, *21*(4), e12626-n/a. https://doi.org/10.1111/desc.12626

Ghanem, N., Denison, S., & Henderson, H. (2025, May). The effect of parents' motivational states on autonomy supporting behaviours during a parent-child problem-solving task. *Society for Research in Child Development Biennial Meeting 2025*. Minneapolis, Minnesota, United States.

Grolnick, W. S., Gurland, S. T., DeCourcey, W., & Jacob, K. (2002). Antecedents and consequences of mothers' autonomy support: An experimental investigation. *Developmental Psychology, 38*(1), 143–155. https://doi.org/10.1037/0012-1649.38.1.143

Grolnick, W. S. (2009). The role of parents in facilitating autonomous self-regulation for education. *Theory and Research in Education*, *7*(2), 164–173. https://doi.org/10.1177/1477878509104321

Grolnick, W. S., & Pomerantz, E. M. (2022). Should parents be involved in their children's schooling? *Theory Into Practice*, *61*(3), 325–335. https://doi.org/10.1080/00405841.2022.2096382

Hustedt, J. T., & Raver, C. C. (2002). Scaffolding in low-income mother-child dyads: Relations with joint attention and dyadic reciprocity. *International Journal of Behavioral Development*, *26*(2), 113–119. https://doi.org/10.1080/01650250042000636

Joussemet, M., & Grolnick, W. S. (2022). Parental consideration of children's experiences: A critical review of parenting constructs. *Journal of Family Theory & Review*, *14*(4), 593–619. https://doi.org/10.1111/jftr.12467

Kallia, E., & Dermitzaki, I. (2017). Assessing maternal behaviors that support children's self-regulated learning. *Hellenic Journal of Psychology, 14*(2), 139–168.

Ladd, G. W., & Pettit, G. S. (2002). Parenting and the development of children's peer relationships. In M. H. Bornstein (Ed.), *Handbook of parenting: Practical issues in parenting* (2nd ed., pp. 269–309). Lawrence Erlbaum Associates Publishers.

Landry, S. H., Garner, P. W., Swank, P. R., & Baldwin, C. D. (1996). Effects of Maternal Scaffolding During Joint Toy Play With Preterm and Full-Term Infants. *Merrill-Palmer Quarterly*, *42*(2), 177–199.

Lerner, R. E., Grolnick, W. S., Caruso, A. J., & Levitt, M. R. (2022). Parental involvement and children's academics: The roles of autonomy support and parents' motivation for involvement. *Contemporary Educational Psychology*, *68*, Article 102039. https://doi.org/10.1016/j.cedpsych.2021.102039

Lunkenheimer, E. (2009). *Dyadic Interaction Coding Manual*. Fort Collins, CO: Colorado State University.

Lunkenheimer, E., Kemp, C. J., Lucas-Thompson, R. G., Cole, P. M., & Albrecht, E. C. (2017). Assessing biobehavioural self-regulation and coregulation in early childhood: The parent-child challenge task. *Infant and Child Development, 26*(1), e1965.

MacNeill, L. A., Fu, X., Buss, K. A., & Pérez-Edgar, K. (2022). Do you see what I mean?: Using mobile eye tracking to capture parent–child dynamics in the context of anxiety risk. *Development and Psychopathology, 34*(3), 997–1012. https://doi.org/10.1017/S0954579420001601

Maurer, M. M., Hiltunen, V., Teuber, Z., & Silinskas, G. (2026). Autonomy support and psychological control by parents and teachers and children's motivation to learn: Longitudinal and interactive effects. *Learning and Individual Differences, 129*, Article 102949. https://doi.org/10.1016/j.lindif.2026.102949

Mermelshtine, R. (2017). Parent–child learning interactions: A review of the literature on scaffolding. *British Journal of Educational Psychology*, *87*(2), 241–254. https://doi.org/10.1111/bjep.12147

Moè, A., Katz, I., & Alesi, M. (2018). Scaffolding for motivation by parents, and child homework motivations and emotions: Effects of a training programme. *British Journal of Educational Psychology*, *88*(2), 323–344. https://doi.org/10.1111/bjep.12216

Mundy, P., Block, J., Delgado, C., Pomares, Y., Van Hecke, A. V., & Parlade, M. V. (2007). Individual differences and the development of joint attention in infancy. *Child development, 78*(3), 938–954. https://doi.org/10.1111/j.1467-8624.2007.01042.x

Neitzel, C., & Stright, A. D. (2003). Mothers' Scaffolding of Children's Problem Solving: Establishing a Foundation of Academic Self-Regulatory Competence. *Journal of Family Psychology*, *17*(1), 147–159. https://doi.org/10.1037/0893-3200.17.1.147

Pöysä-Tarhonen, J., Awwal, N., Häkkinen, P., & Otieno, S. (2021). Joint attention behaviour in remote collaborative problem solving: exploring different attentional levels in dyadic interaction. *Research and Practice in Technology Enhanced Learning*, *16*(1), Article 11. https://doi.org/10.1186/s41039-021-00160-0

Pratt, M. W., Kerig, P., Cowan, P. A., & Cowan, C. P. (1988). Mothers and Fathers Teaching 3-Year-Olds: Authoritative Parenting and Adult Scaffolding of Young Children's Learning. *Developmental Psychology*, *24*(6), 832–839. https://doi.org/10.1037/0012-1649.24.6.832

Raver, C. C., & Leadbeater, B. J. (1995). Factors influencing joint attention between socioeconomically disadvantaged adolescent mothers and their infants. In C. Moore & P.

J. Dunham (Eds.), *Joint attention: Its origins and role in development* (pp. 251–271). Lawrence Erlbaum Associates, Inc.

Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: basic psychological needs in motivation, development, and wellness*. The Guilford Press.

Schneider, B., & Pea, R. (2013). Real-time mutual gaze perception enhances collaborative learning and collaboration quality. *International Journal of Computer-Supported Collaborative Learning*, *8*(4), 375–397. https://doi.org/10.1007/s11412-013-9181-4

Schroer, S. E., Peters, R. E., & Yu, C. (2024). Consistency and Variability in Multimodal Parent-Child Social Interaction: An At-Home Study Using Head-Mounted Eye Trackers. *Developmental Psychology*, *60*(8), 1432–1446. https://doi.org/10.1037/dev0001756

Striano, T. and Stahl, D. (2005), Sensitivity to triadic attention in early infancy. Developmental Science, 8: 333-343. https://doi.org/10.1111/j.1467-7687.2005.00421.x

Vygotsky, L. S. (1978). *Mind in Society: Development of Higher Psychological Processes* (M. Cole, V. Jolm-Steiner, S. Scribner, & E. Souberman, Eds.). Harvard University Press. https://doi.org/10.2307/j.ctvjf9vz4

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology & Psychiatry & Allied Disciplines, 17*(2), 89–100. https://doi-org.proxy.lib.uwaterloo.ca/10.1111/j.1469-7610.1976.tb00381.x

Wood, D., & Middleton, D. (1975). A study of assisted problem-solving. *The British Journal of Psychology*, *66*(2), 181–191. https://doi.org/10.1111/j.2044-8295.1975.tb01454.x

Wuyts, D., Vansteenkiste, M., Mabbe, E., & Soenens, B. (2017). Effects of social pressure and child failure on parents' use of control: An experimental investigation. *Contemporary Educational Psychology*, *51*, 378–390. https://doi.org/10.1016/j.cedpsych.2017.09.010

Yu, C., & Smith, L. B. (2016). The Social Origins of Sustained Attention in One-Year-Old Human Infants. *Current biology : CB*, *26*(9), 1235–1240. https://doi.org/10.1016/j.cub.2016.03.026

Yu, C., & Smith, L. B. (2017). Hand-Eye Coordination Predicts Joint Attention. *Child Development*, *88*(6), 2060–2078. https://doi.org/10.1111/cdev.12730

Zhang, H., & Whitebread, D. (2019). Identifying characteristics of parental autonomy support and control in parent-child interactions. *Early Child Development and Care*, *191*(2), 307–320. https://doi.org/10.1080/03004430.2019.1621303

APPENDIX A

Study Protocol

Study Protocol

E = Experimenter; RA = Research Assistant

Before Session Checklist:

- Check if parents completed consent form and questionnaires on Qualtrics
- Fill out participant tracking sheet with info
- Check condition the dyad is assigned to and note on study protocol
- Make sure eye trackers are set-up and working
- Open PSLiveCapture on both laptops
  - Check audio input – should be "USB"
  - Create new folder with participant ID (e.g., 001-P, 001-C)
- Turn on remote third-view cameras, insert SD card
- Set up 8-minute timer on phone
- Hit **record** on both laptops and third-view camera using remote control

Part 1: Parent-Child Challenge Task

E (to parent and child): Good ____ (morning, afternoon, evening)! Thank you so much for taking the time to meet with us today! My name is ____and I am a [graduate student, research assistant] at the Developmental Learning Lab and Social Development Lab that is directed by Dr. Stephanie Denison and Dr. Heather Henderson at the University of Waterloo.

Thank you for filling out the consent form and questionnaires. So, [child name], me and a few other people are working on a project that looks at how children and parents solve problems. You and your mom/dad are going to put this eye tracker on you which will show me exactly what you're looking at and then you will work on some puzzles together. Then, you will get a chance to build something on your own and set up a stuffed animal picnic. Does that sound like something you want to do?

Okay, so before we get started, we will get you both set up with the eye trackers. [Parent name], we'll start with you. You can place the strap over your head and wear the eye tracker like you would wear glasses. If it feels too tight or loose, let me know so I can adjust the strap for you.

RA in control room should be checking to make sure eye tracking cameras are adjusted properly on the laptop (eye camera: green box should be at the corner of eyes and eyelashes, pupil should be within light blue box, blue dot on center of pupil; scene camera: make sure it is straight, not rotated at all)
Okay, [child name], now it's your turn! I'm going to help you with putting this eye tracker on. Let me know if it feels too tight or loose and I can adjust it for you.

RA check eye and scene cameras

Now, to make sure the eye trackers work properly during the study, we're going to do a quick calibration. [Research assistant name] will come in and help you out with that while I check the computers.

RA: Both of you will be following my finger while I point to the different objects on the board. Make sure you keep your head really still and only move your eyes the whole time. I'm going to count to 10 at each object and I want you to try and stay still while I count. Does that make sense?

RA holds finger at each calibration point for 10 seconds; E makes calibration points on laptop and clicks "Calibrate" when finished

If E did not find some calibration points to be adequate or RA notices child not looking where asked, repeat calibration process.*

Now that we have the eye trackers set up, we're ready to start.

E move calibration board off easel and replace with magnetic board. Place mini white boards in front of parent and child

So, we're going to give you 3 puzzles for [child's name] to complete in 8 minutes. You will each have your own set of pieces that you will need to complete these puzzles together. [Parent name], you will be allowed to give verbal help to [child's name], but not physical help. So, the only time you will be touching the puzzle pieces is when you are asked for pieces from your pile. Does that make sense?

IF ASSIGNED TO PROCESS-ORIENTED CONDITION:
E (to parent): The MOST important thing is to focus on your child's learning experience. Try to enjoy the process and guide and support your child as they work through the puzzles.

IF ASSIGNED TO OUTCOME-ORIENTED CONDITION:
E (to parent): The MOST important thing is to focus on getting the puzzles done. For us to get ALL the information we need, it's REALLY important that your child completes the 3 puzzles in 8 minutes.

E: I'll be staying in the room just to switch out the puzzle boards and pieces as you complete them. You can begin as soon as I put the first puzzle in front of you.

E place puzzle picture on board and start 8-minute timer
When task is over, RA hits "stop recording" and "create movie" on both laptops

Part 2: Lego Task

E: For the next activity, we're going to remove the eye tracker off of both of you. [Parent name], we're going to have you sit to the side over here while [child name] completes the next

two tasks on their own. You are welcome to look at these magazines or do whatever you'd like during this time. [Hand card to parent about independent tasks]

[Child name], you are going to be building some Lego. **Place Lego model and pieces on table** I am going to give you 8 minutes to try to copy this Lego model using these pieces in front of you. I am going to leave the room and come back when time is up.

E start 8-minute timer

When time is up: Thank you for working on that for all 8 minutes! You got so much done in that time.

Part 3: Picnic Task

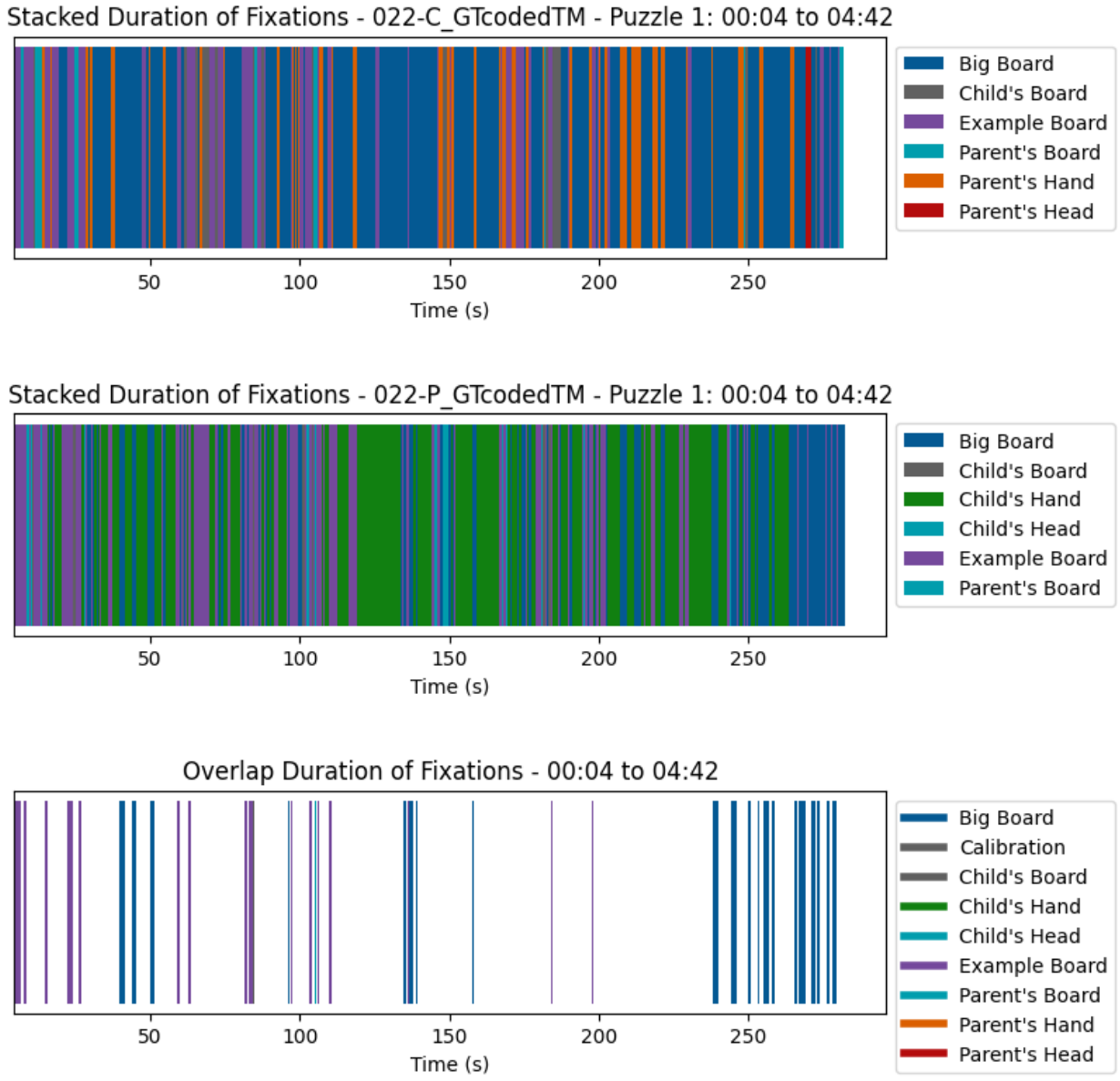
Move Lego and place basket of items on table
E: For the last activity, we have a basket of toys here for you to play with. We want you to use ALL of these toys to make a stuffed animal picnic! I'll be outside the room and will come back when you're done.

Part 4: Thank you
Okay, we are all done! Thank you both so much for your help today! Here is your $25 Indigo gift card. Do you have any questions at all? Great, thank you again for participating in our study!

APPENDIX B

Figure B1.1

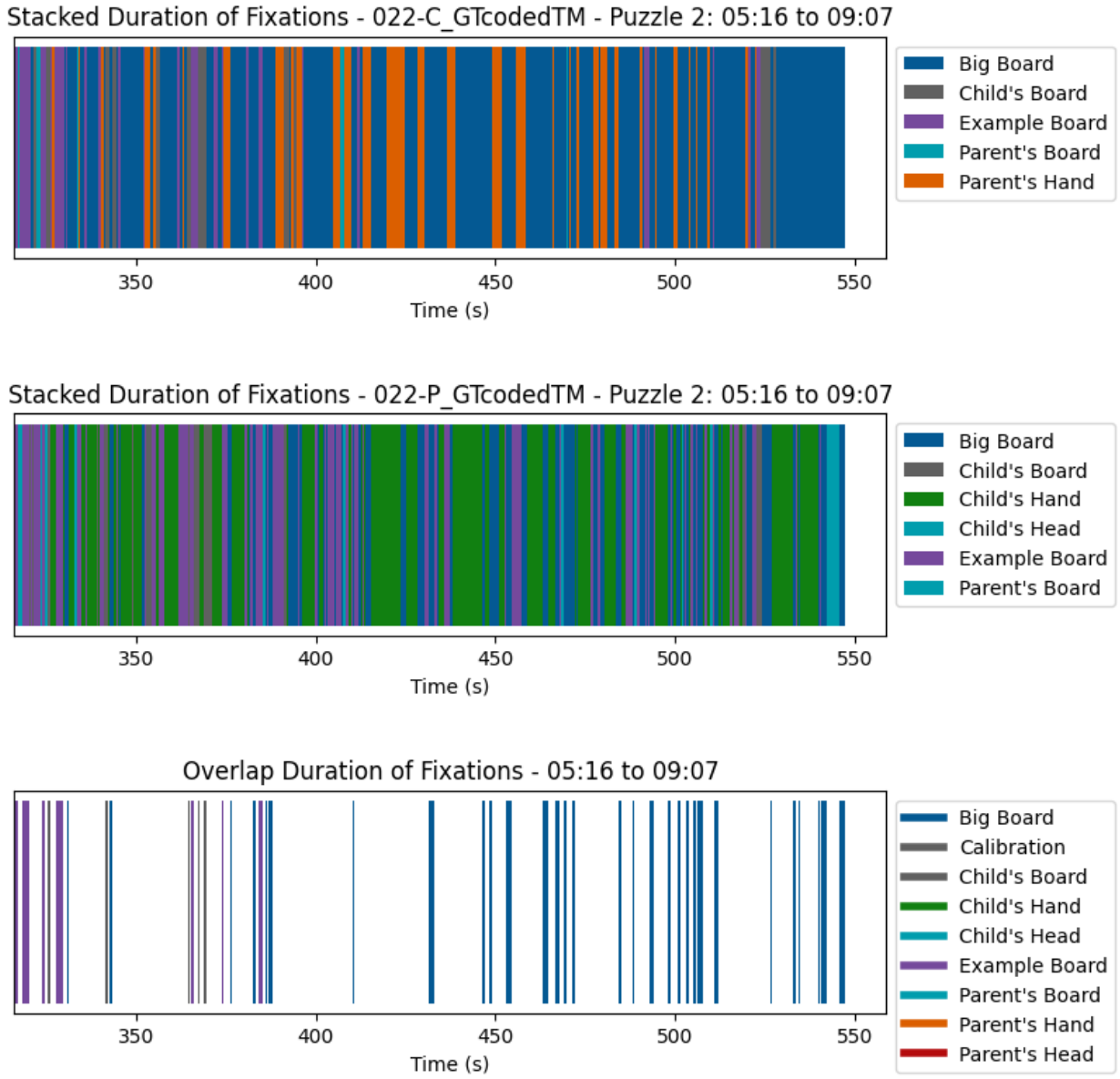
Eye-Tracking Visualization of Dyad 022 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B1.2

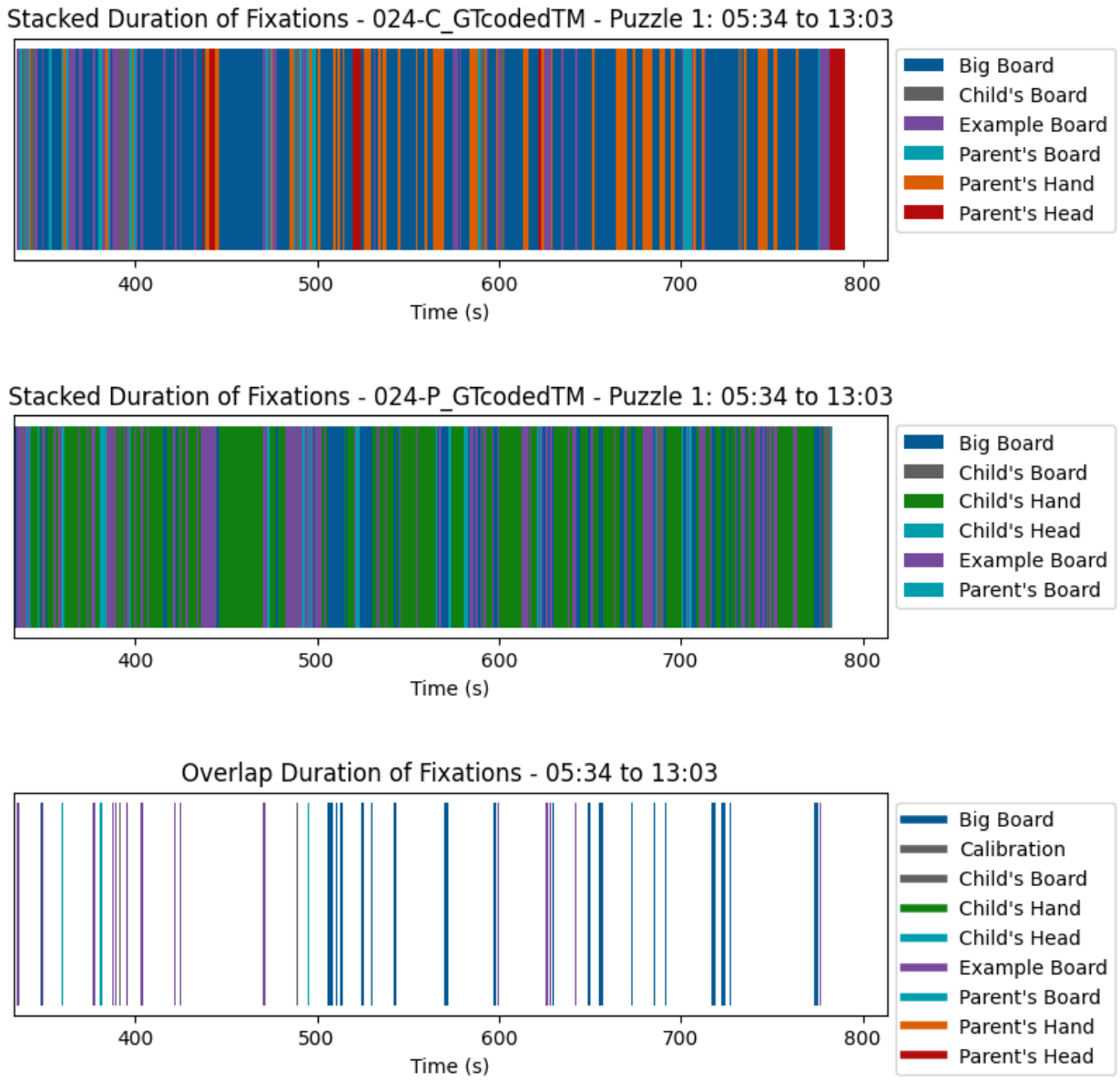
Eye-Tracking Visualization of Dyad 022 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B2.1

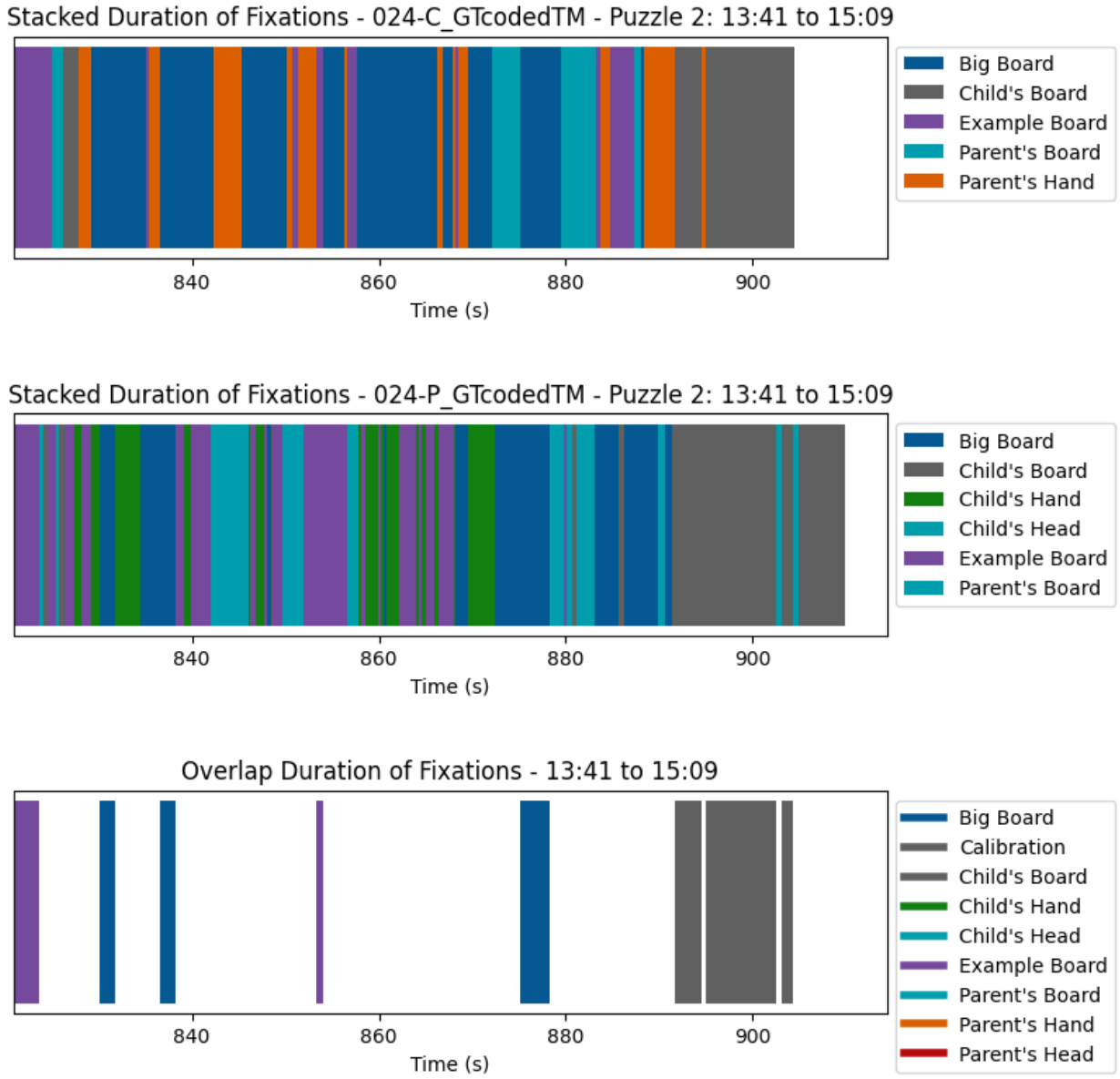
Eye-Tracking Visualization of Dyad 024 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B2.2

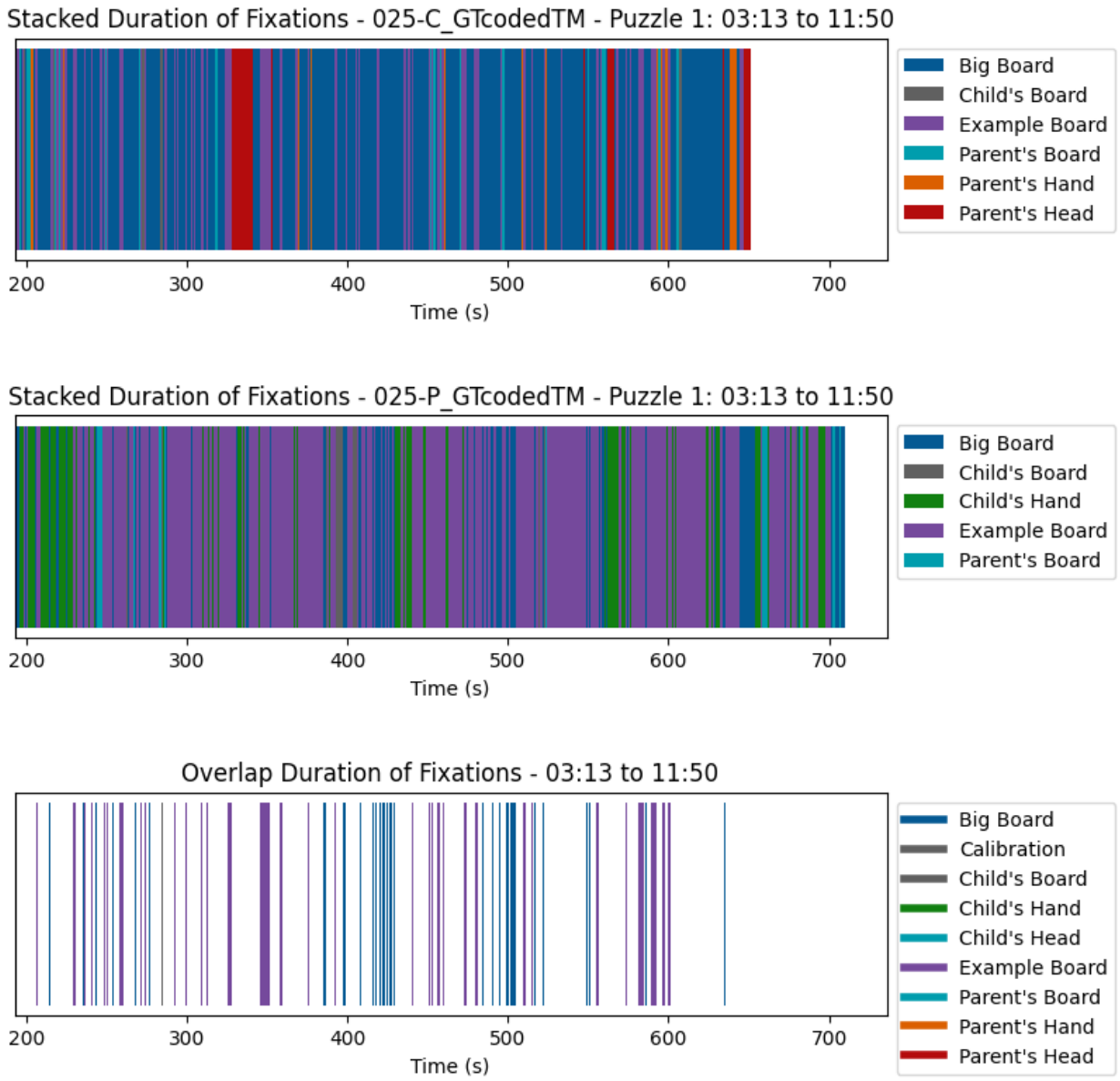
Eye-Tracking Visualization of Dyad 024 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B3.1

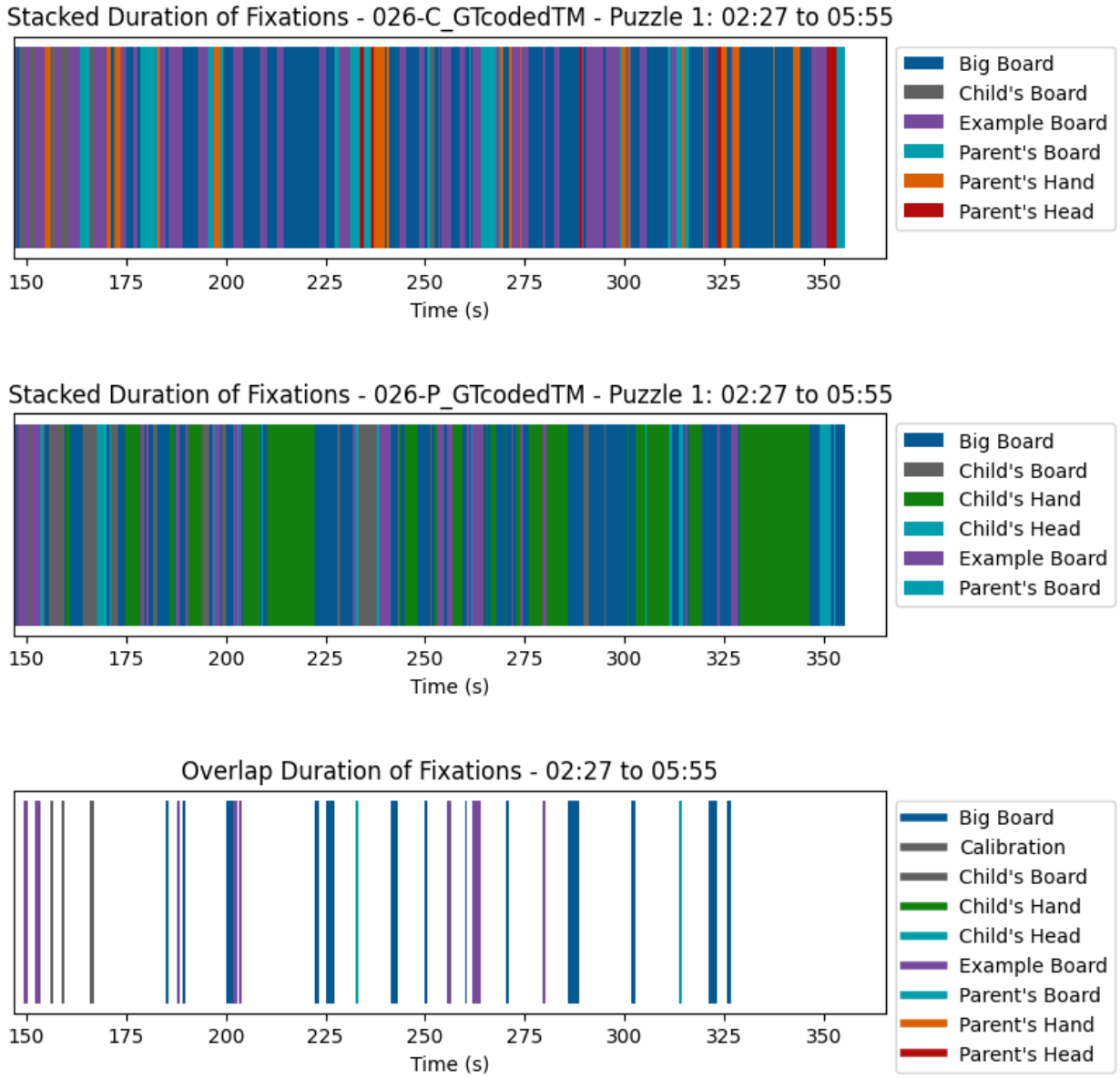
Eye-Tracking Visualization of Dyad 025 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B4.1

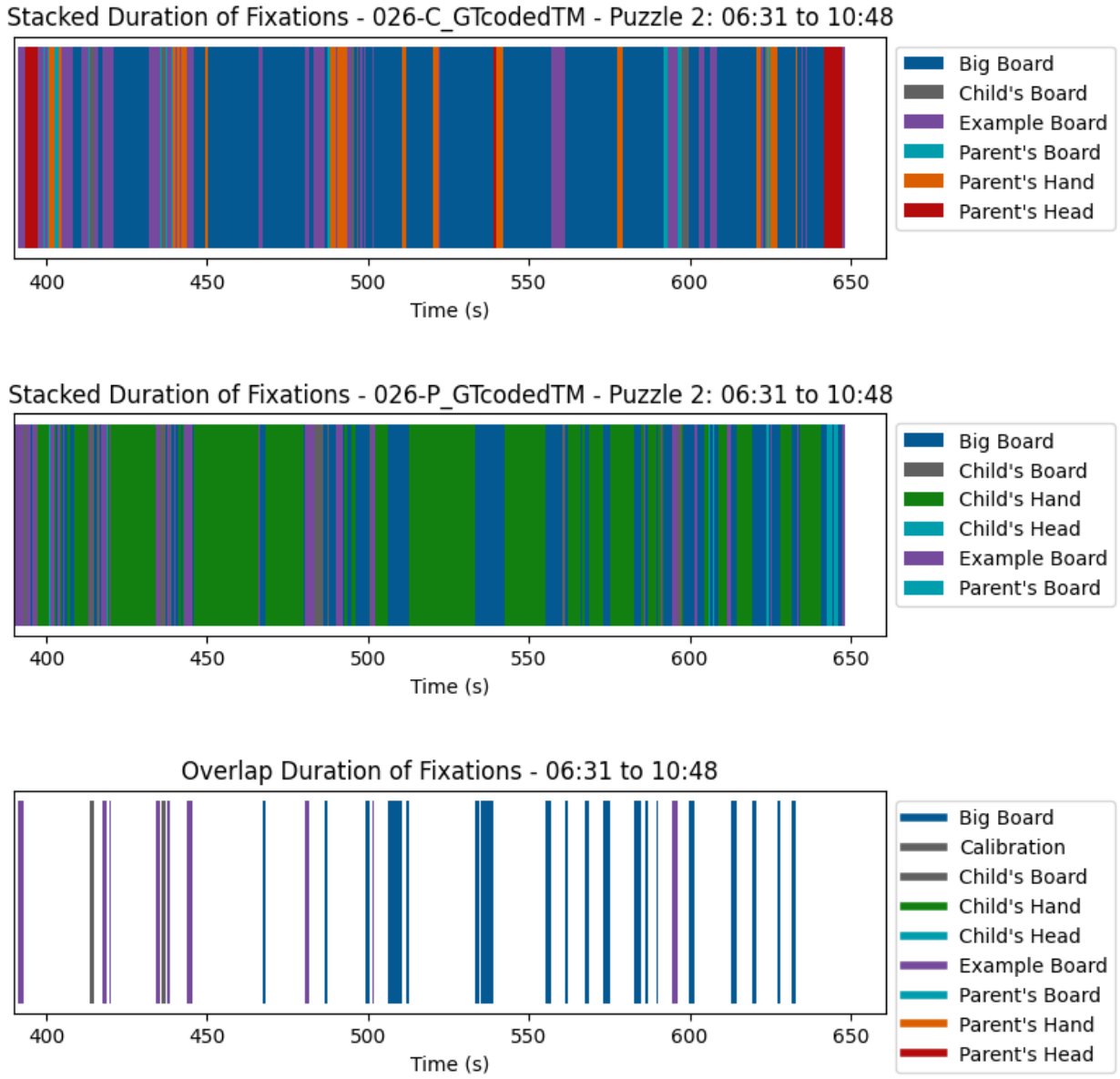
Eye-Tracking Visualization of Dyad 026 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B4.2

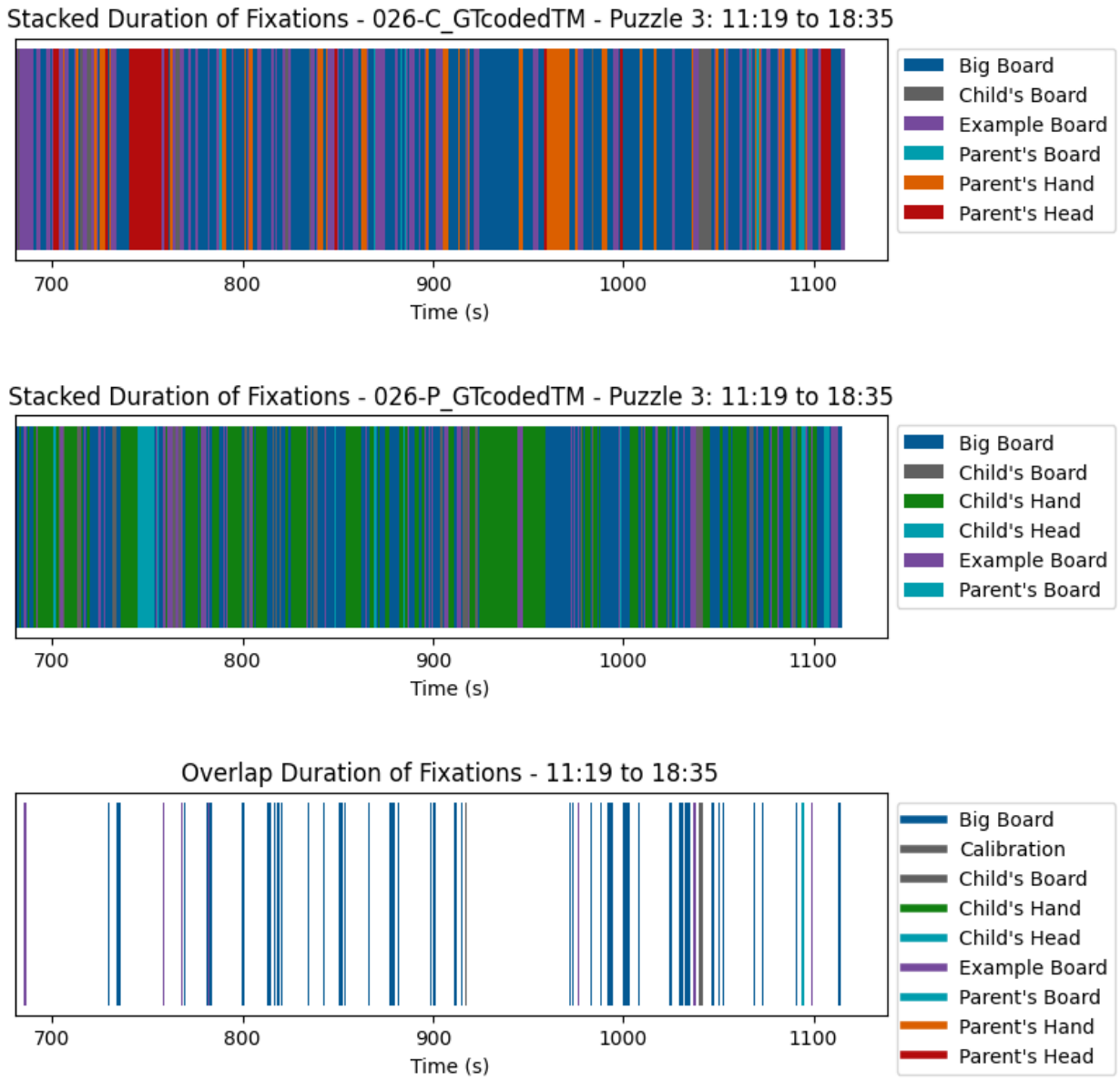
Eye-Tracking Visualization of Dyad 026 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B4.3

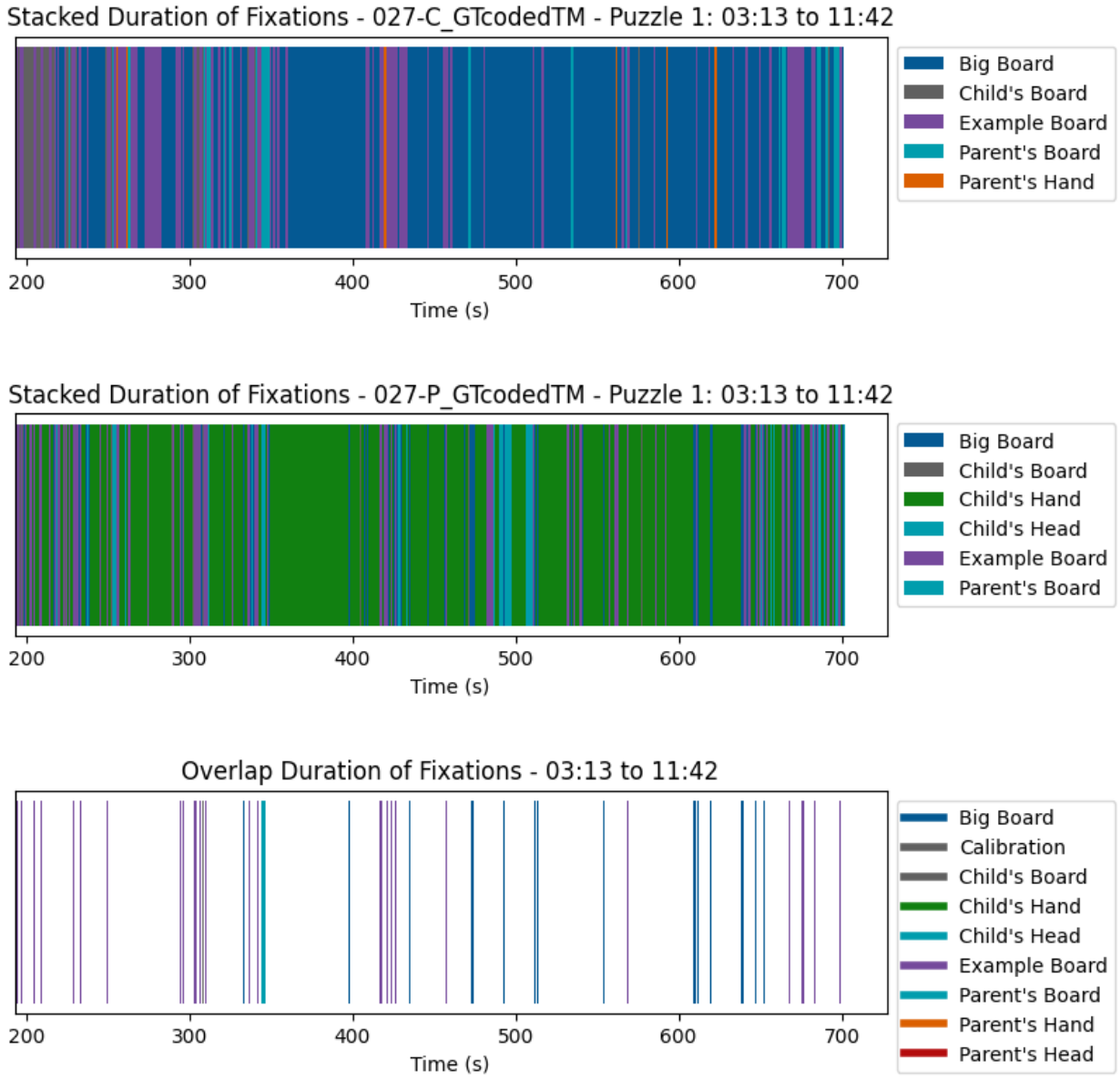
Eye-Tracking Visualization of Dyad 026 Puzzle 3



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B5.1

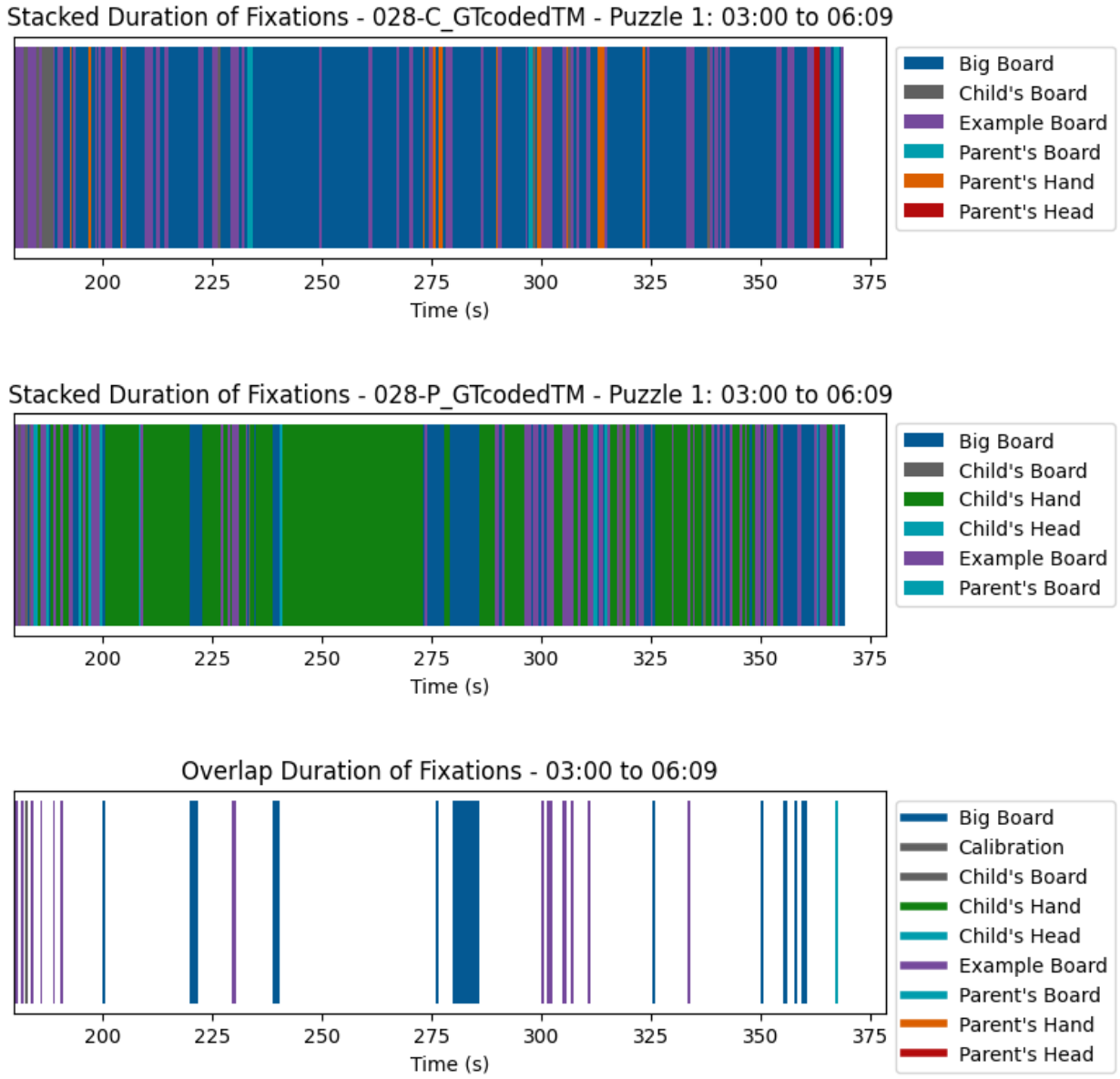
Eye-Tracking Visualization of Dyad 027 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B6.1

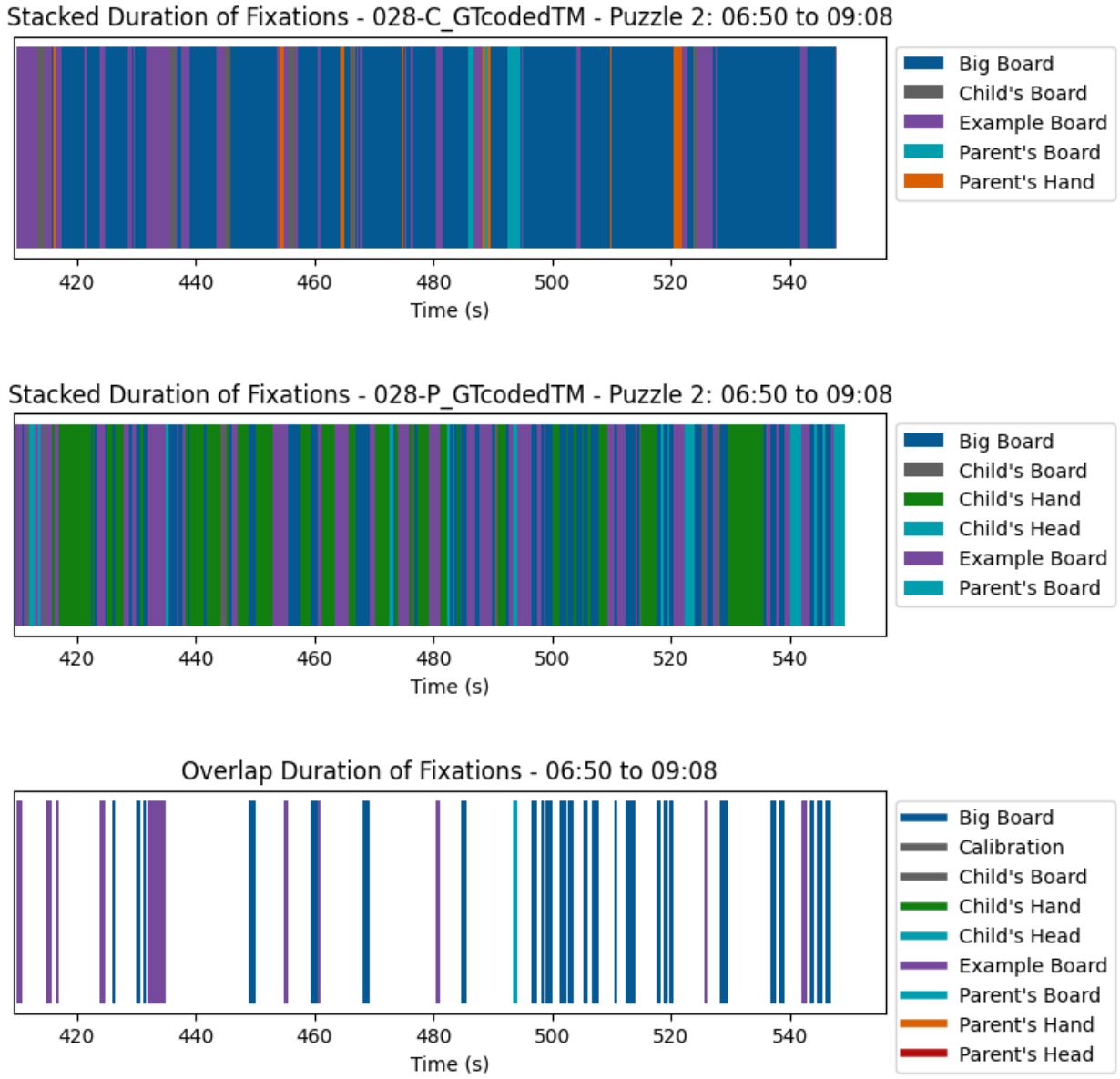
Eye-Tracking Visualization of Dyad 028 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B6.2

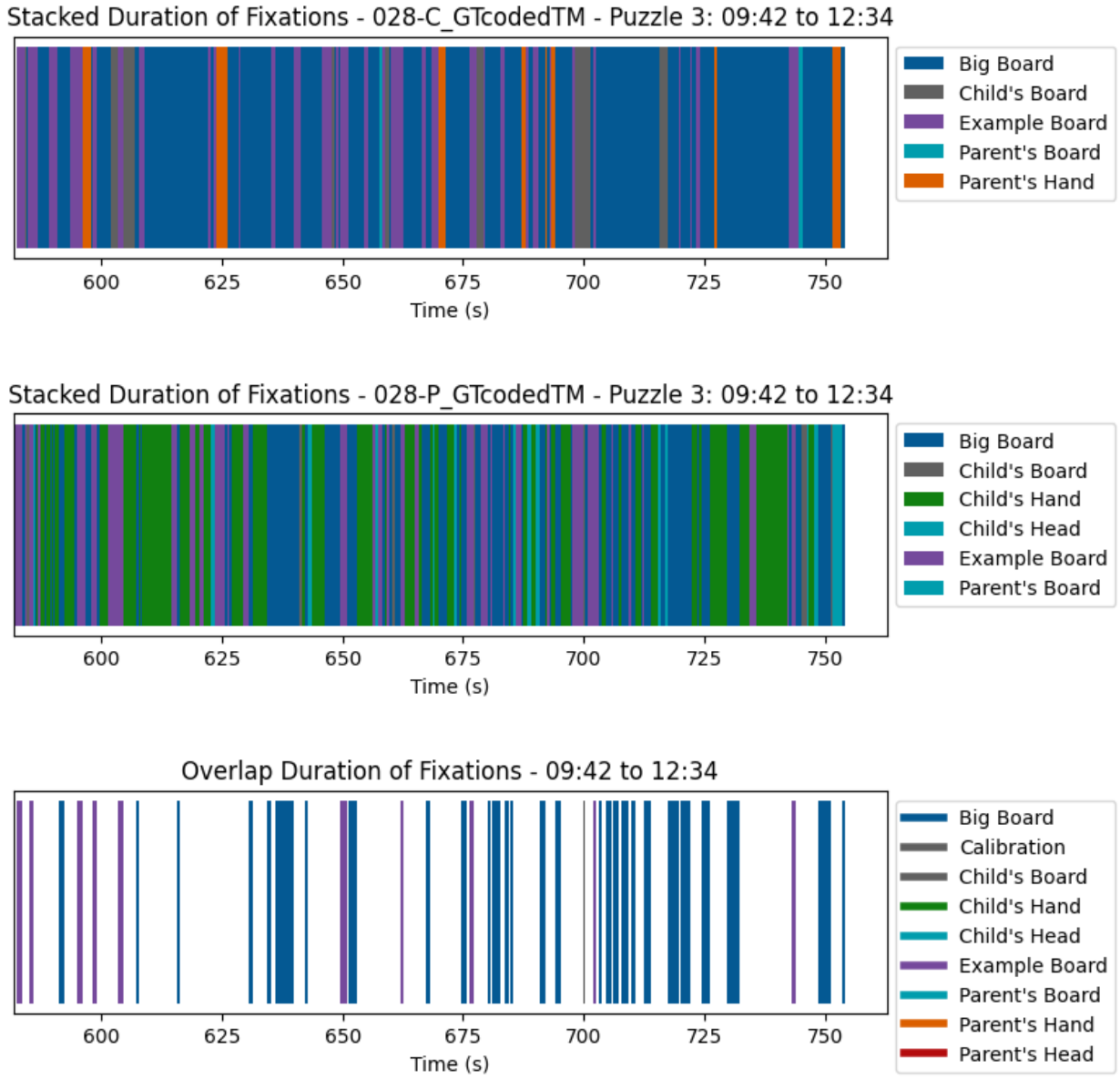
Eye-Tracking Visualization of Dyad 028 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B6.3

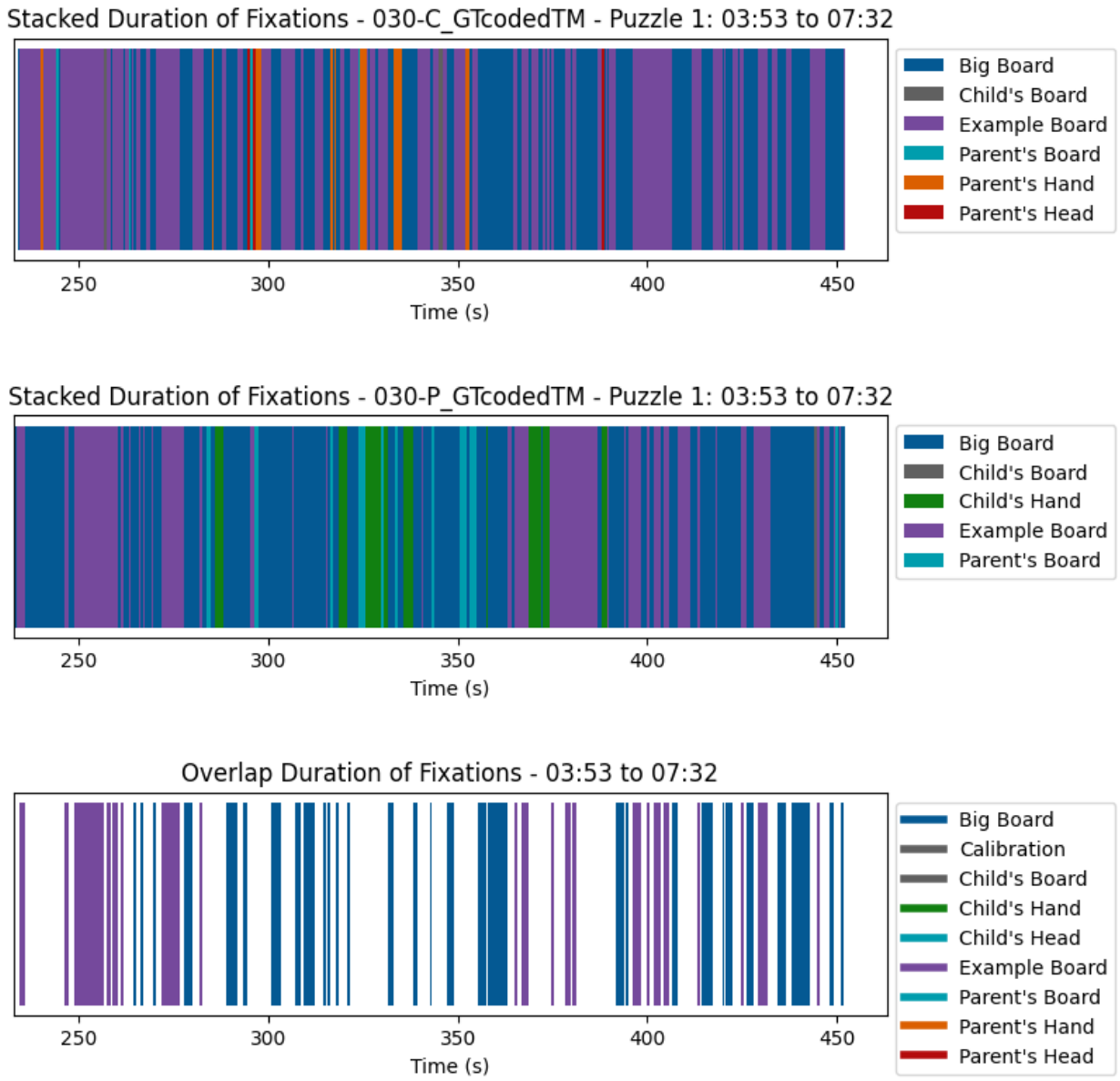
Eye-Tracking Visualization of Dyad 028 Puzzle 3



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B7.1

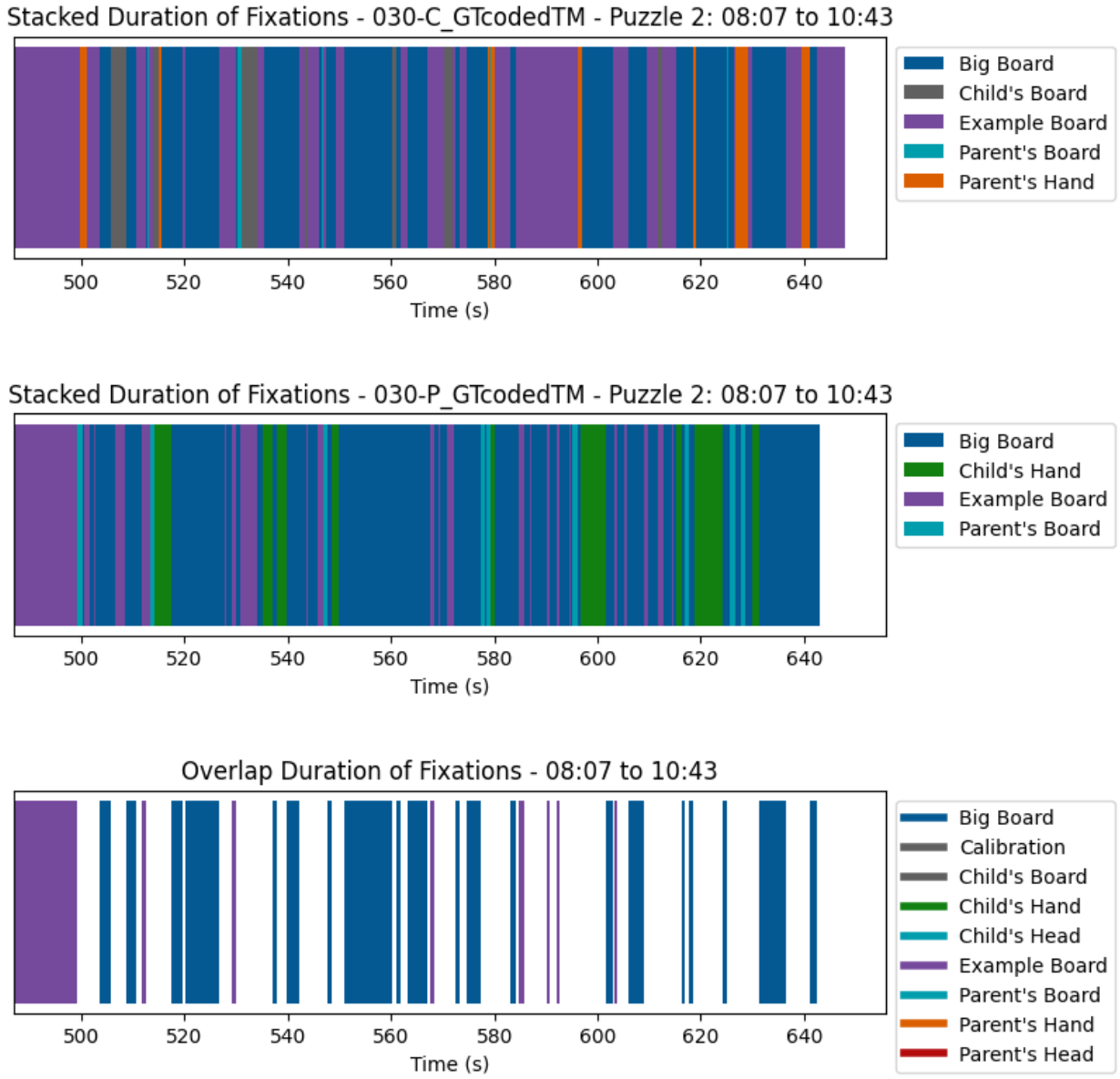
Eye-Tracking Visualization of Dyad 030 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B7.2

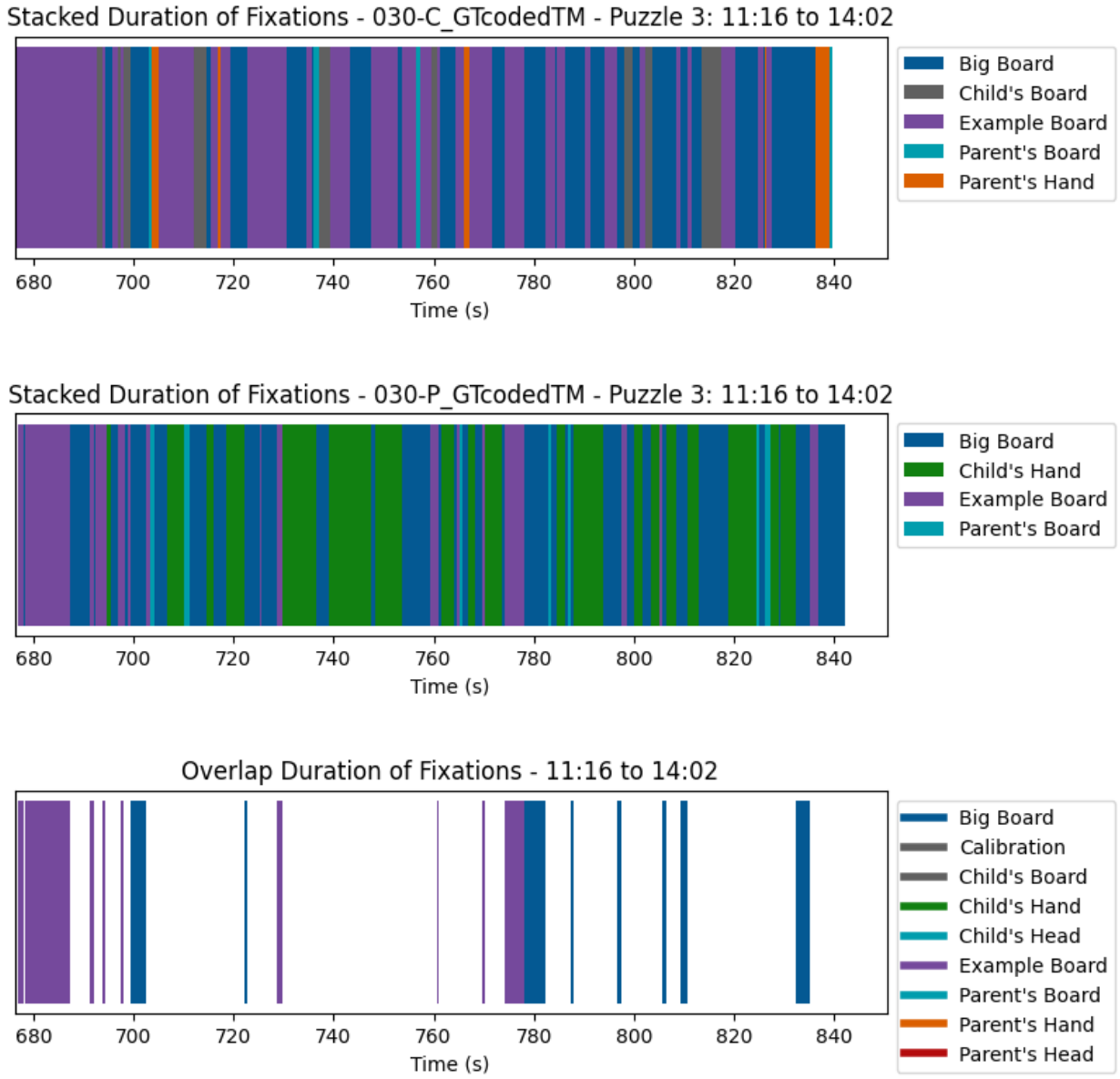
Eye-Tracking Visualization of Dyad 030 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B7.3

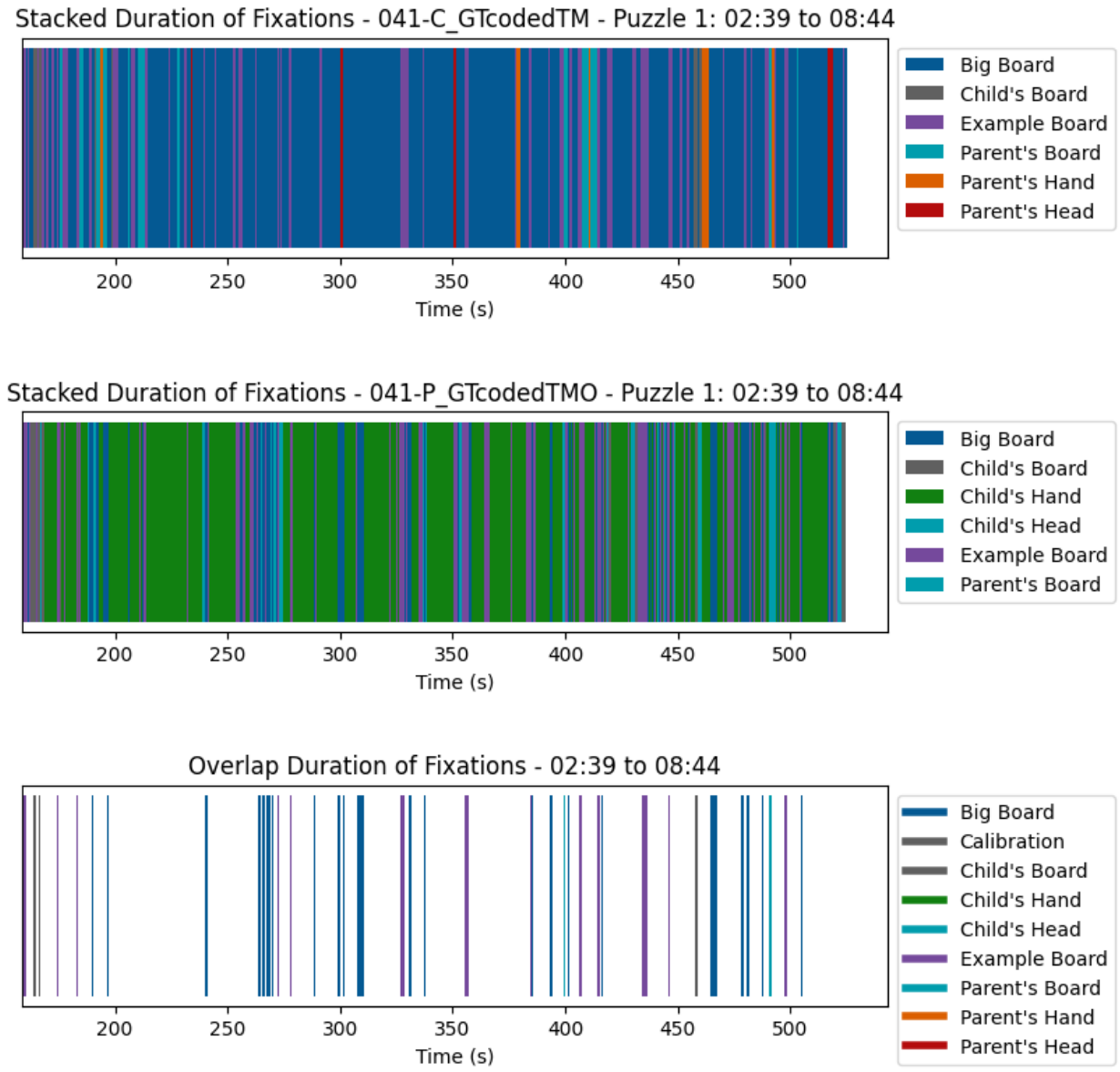
Eye-Tracking Visualization of Dyad 030 Puzzle 3



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B8.1

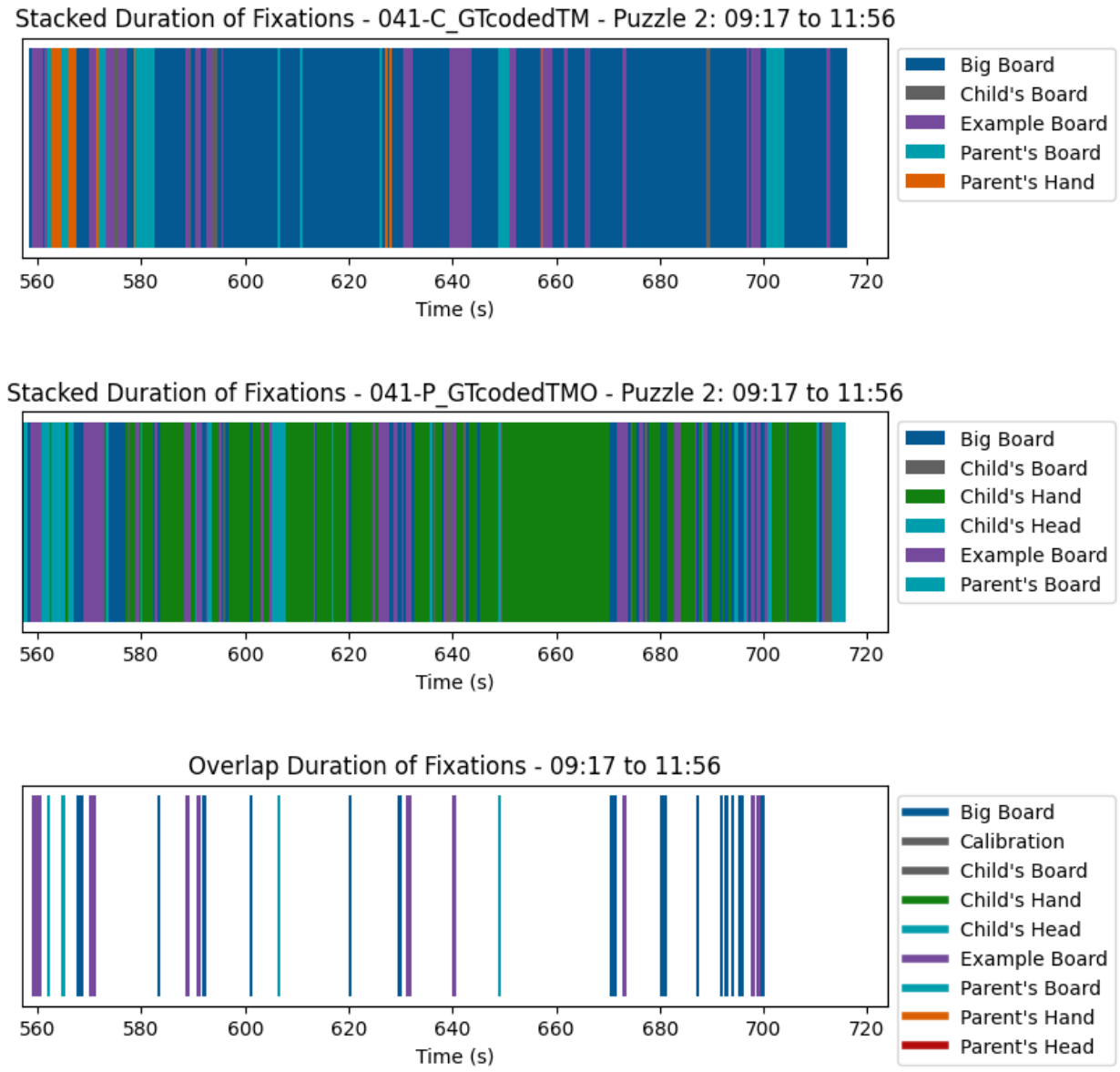
Eye-Tracking Visualization of Dyad 041 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B8.2

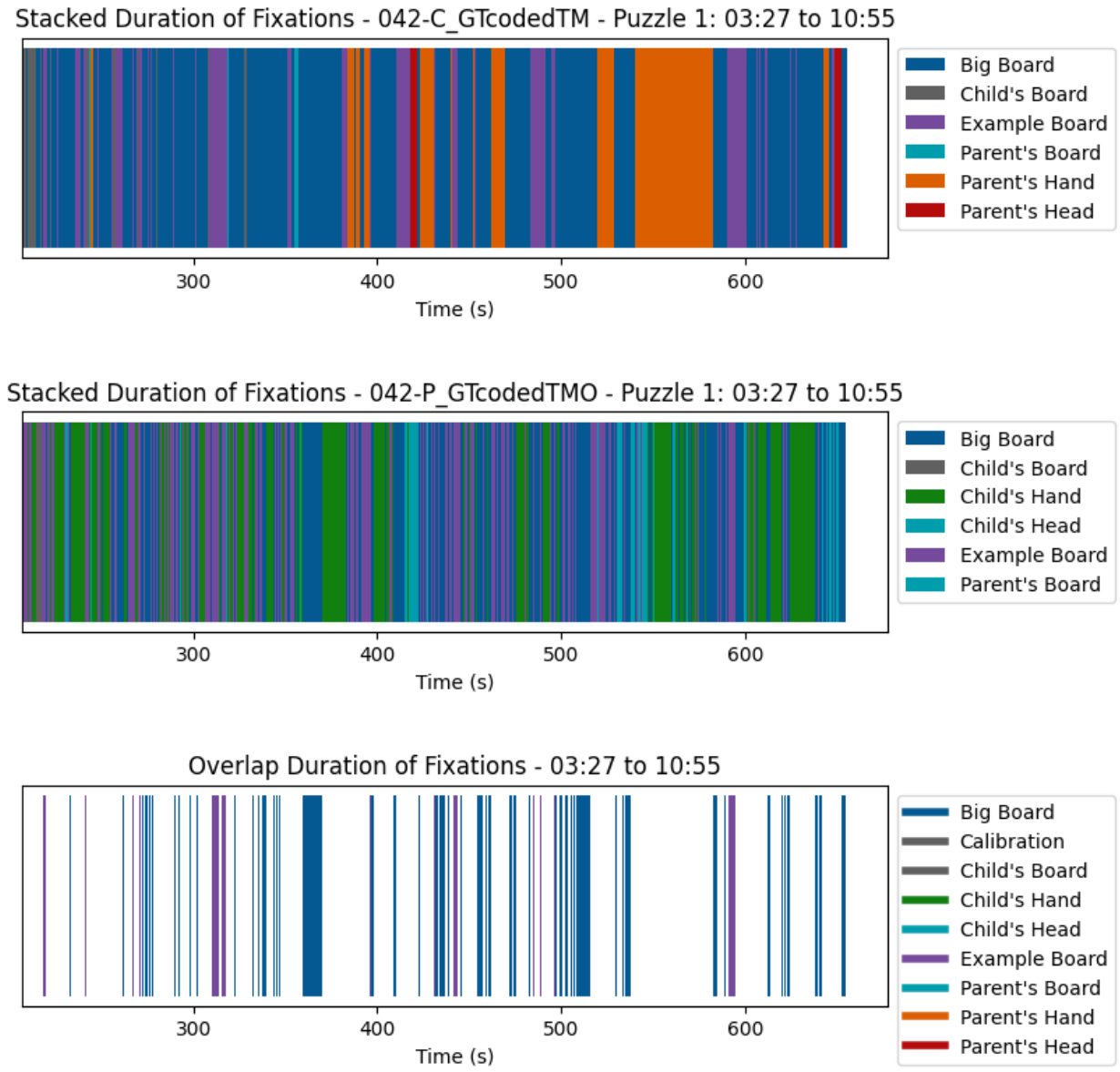
Eye-Tracking Visualization of Dyad 041 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B9.1

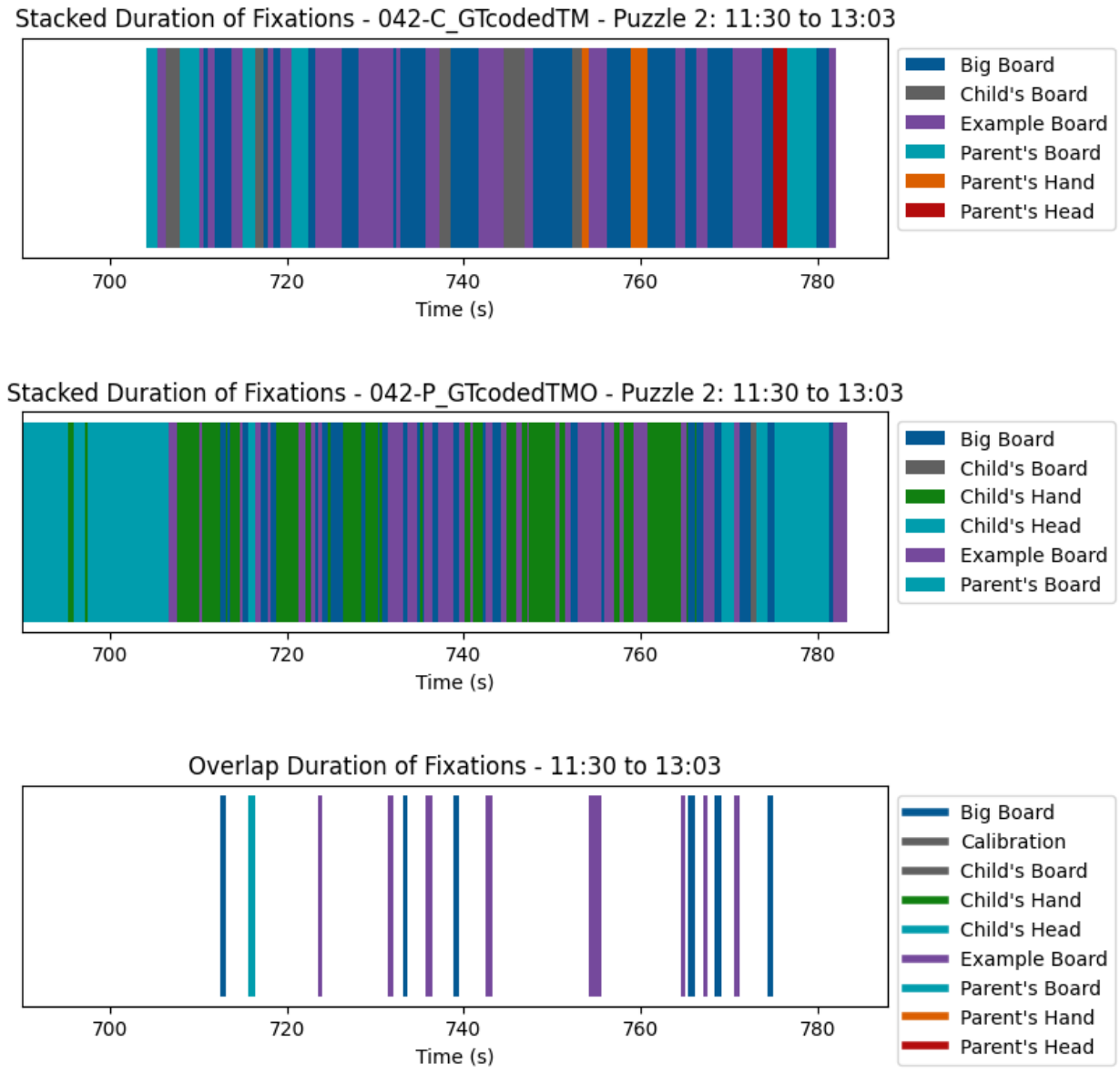
Eye-Tracking Visualization of Dyad 042 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B9.2

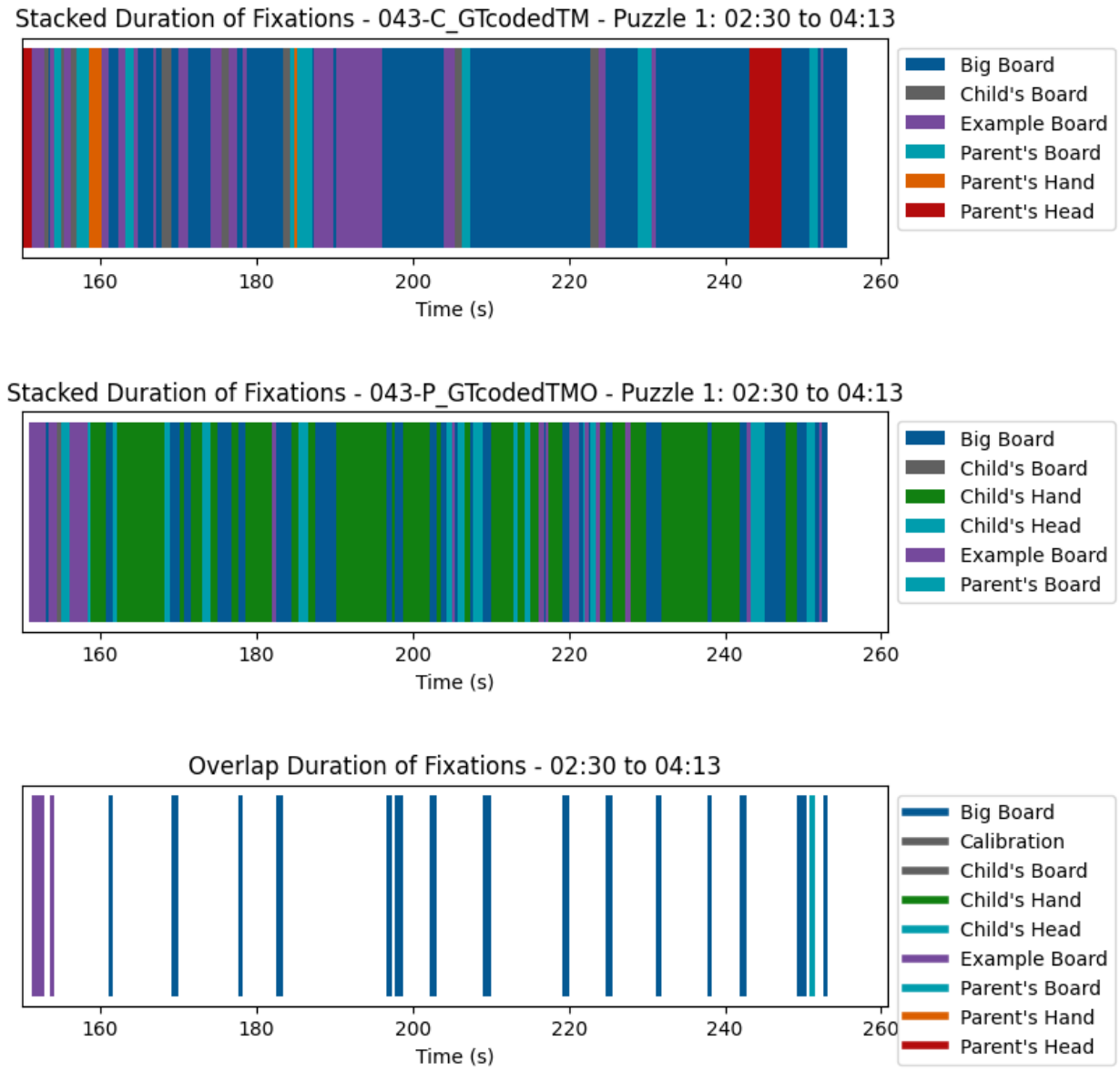
Eye-Tracking Visualization of Dyad 042 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B10.1

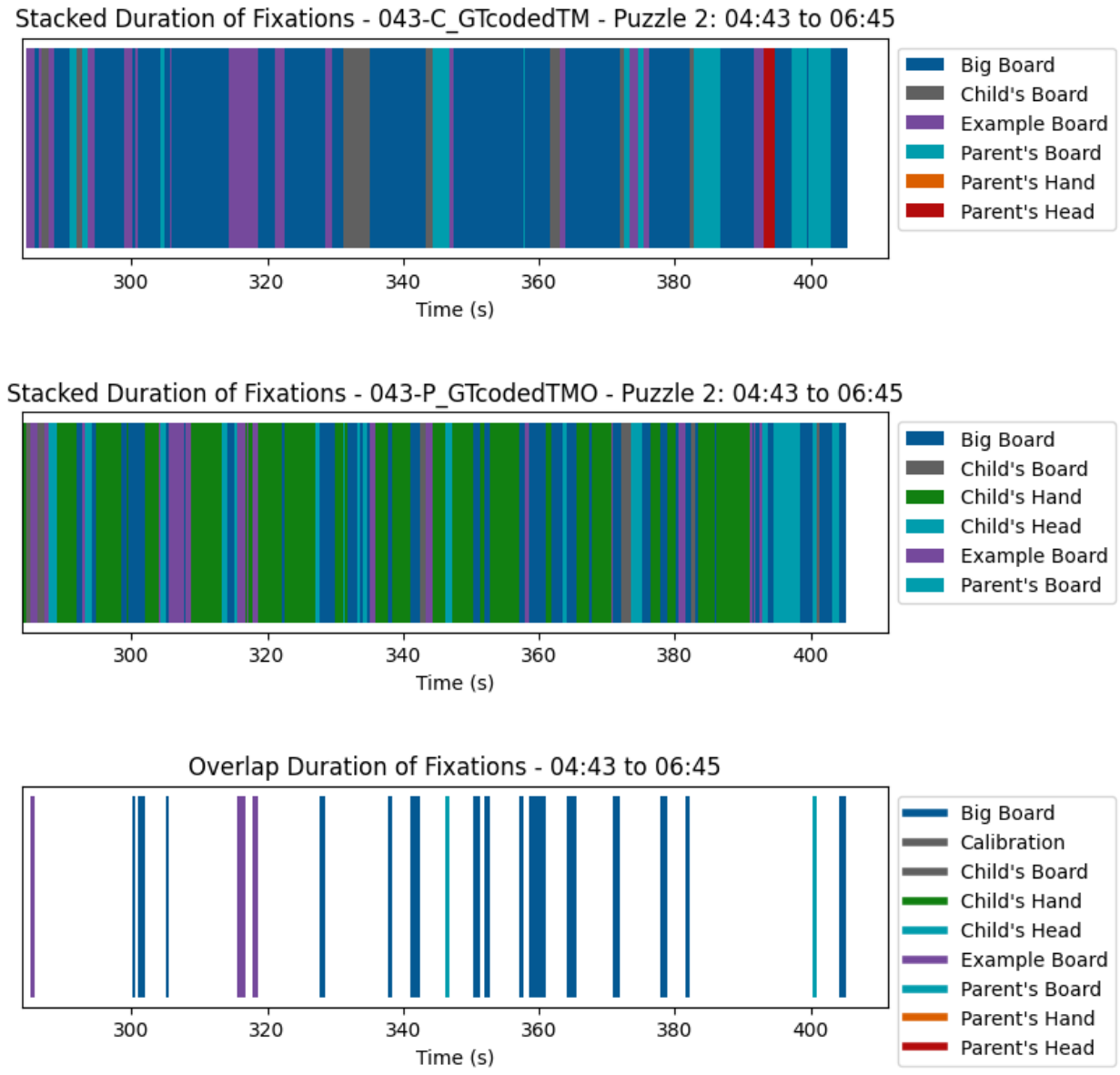
Eye-Tracking Visualization of Dyad 043 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B10.2

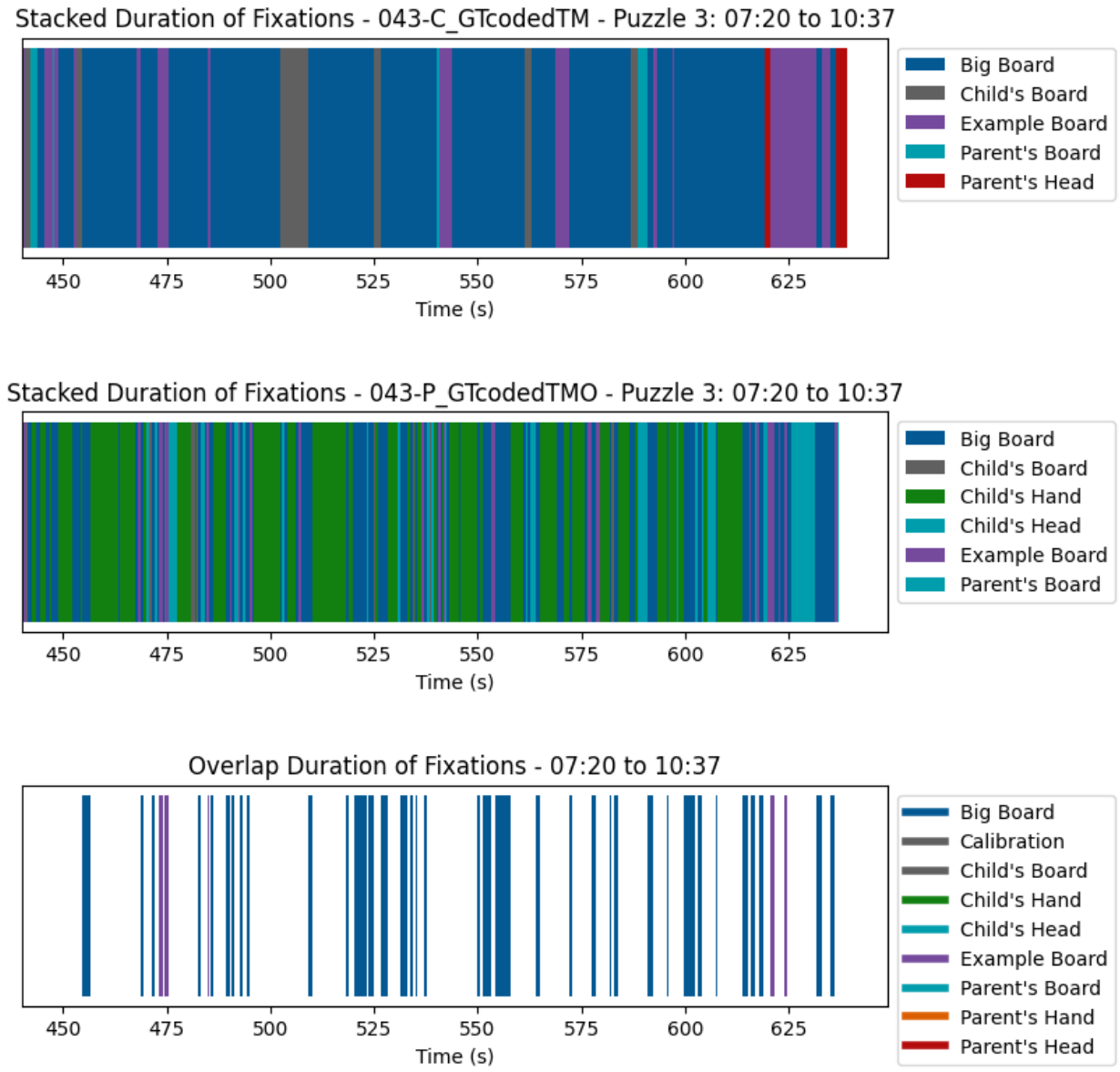
Eye-Tracking Visualization of Dyad 043 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B10.3

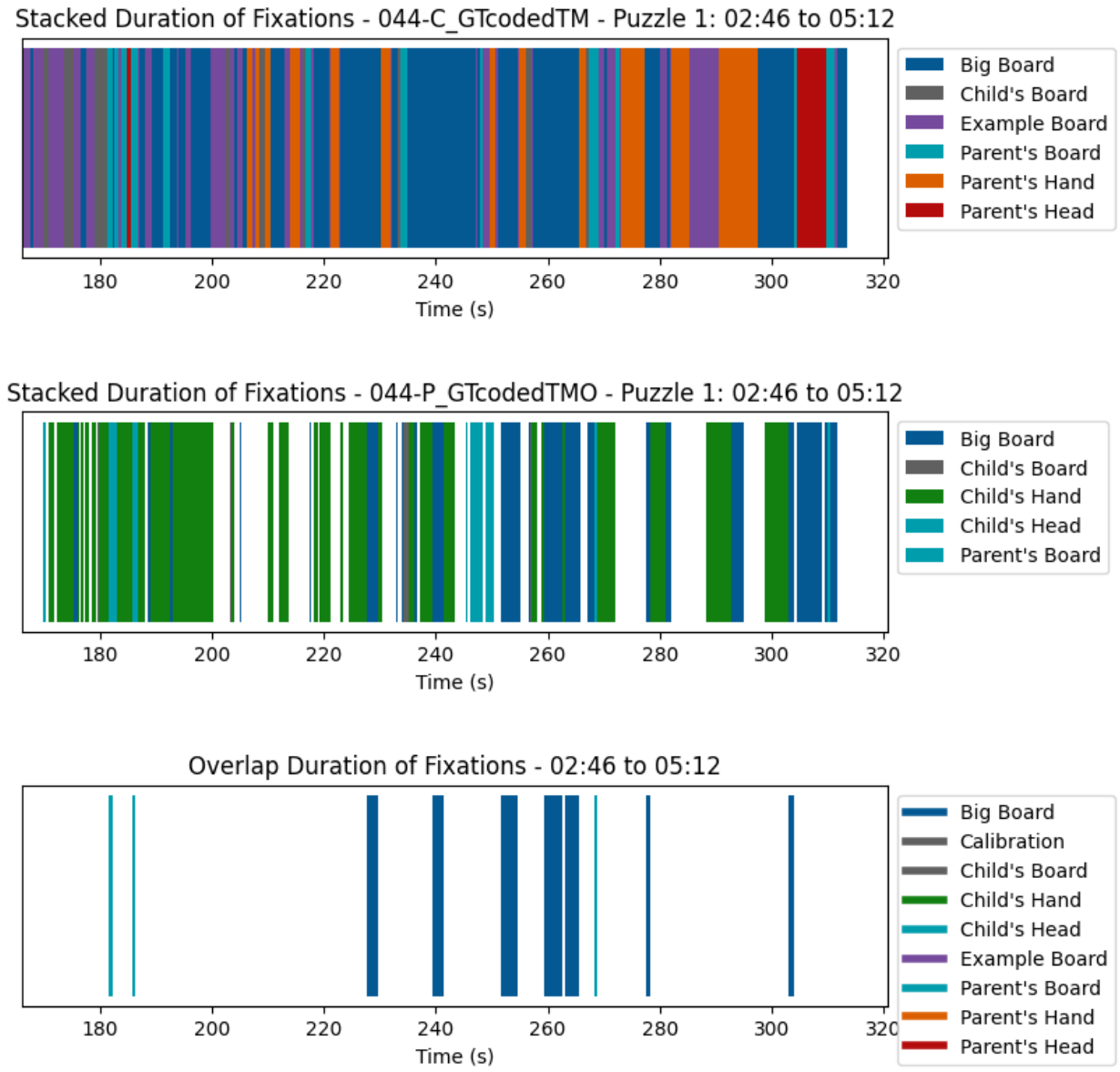
Eye-Tracking Visualization of Dyad 043 Puzzle 3



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B11.1

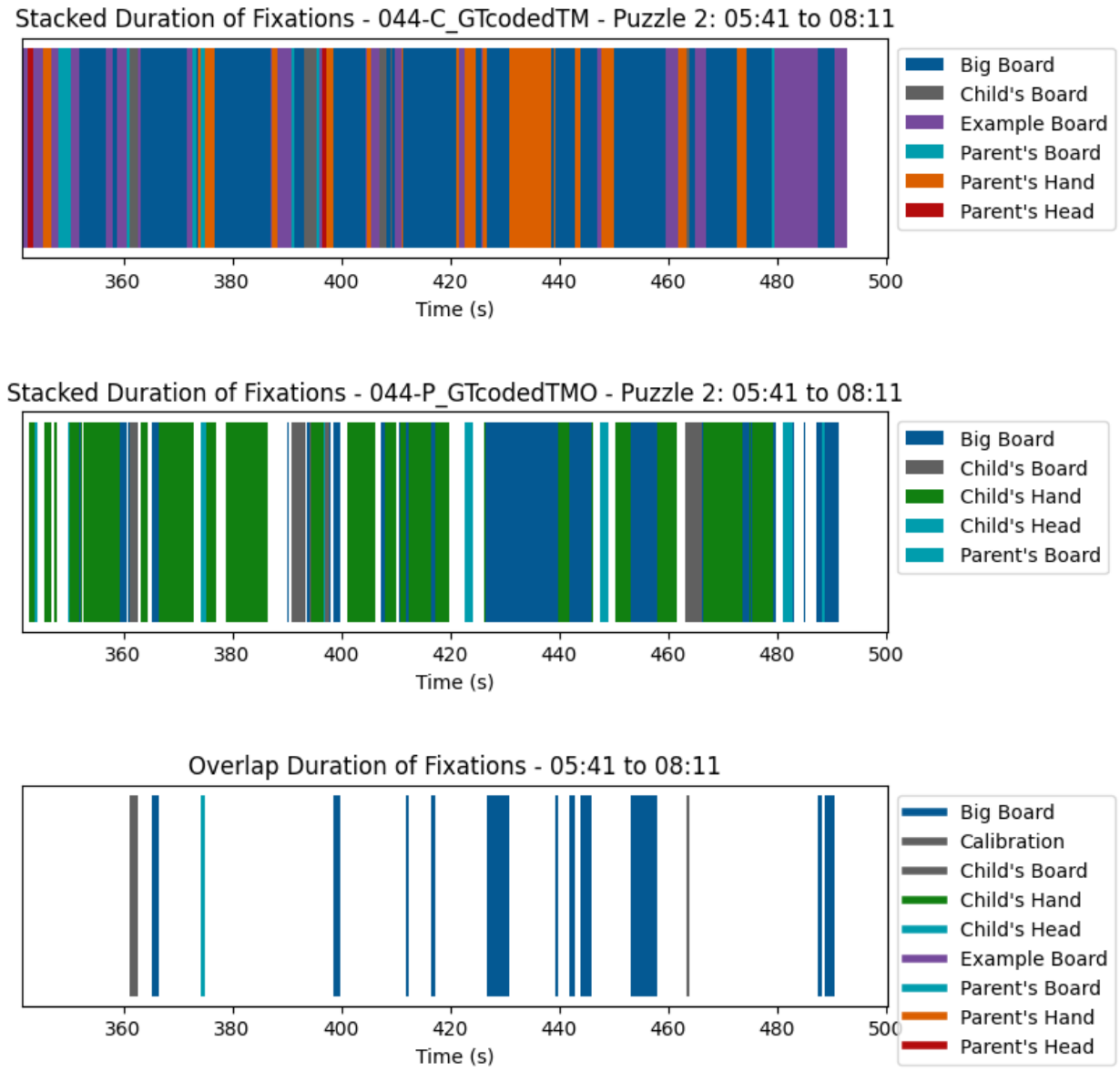
Eye-Tracking Visualization of Dyad 044 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B11.2

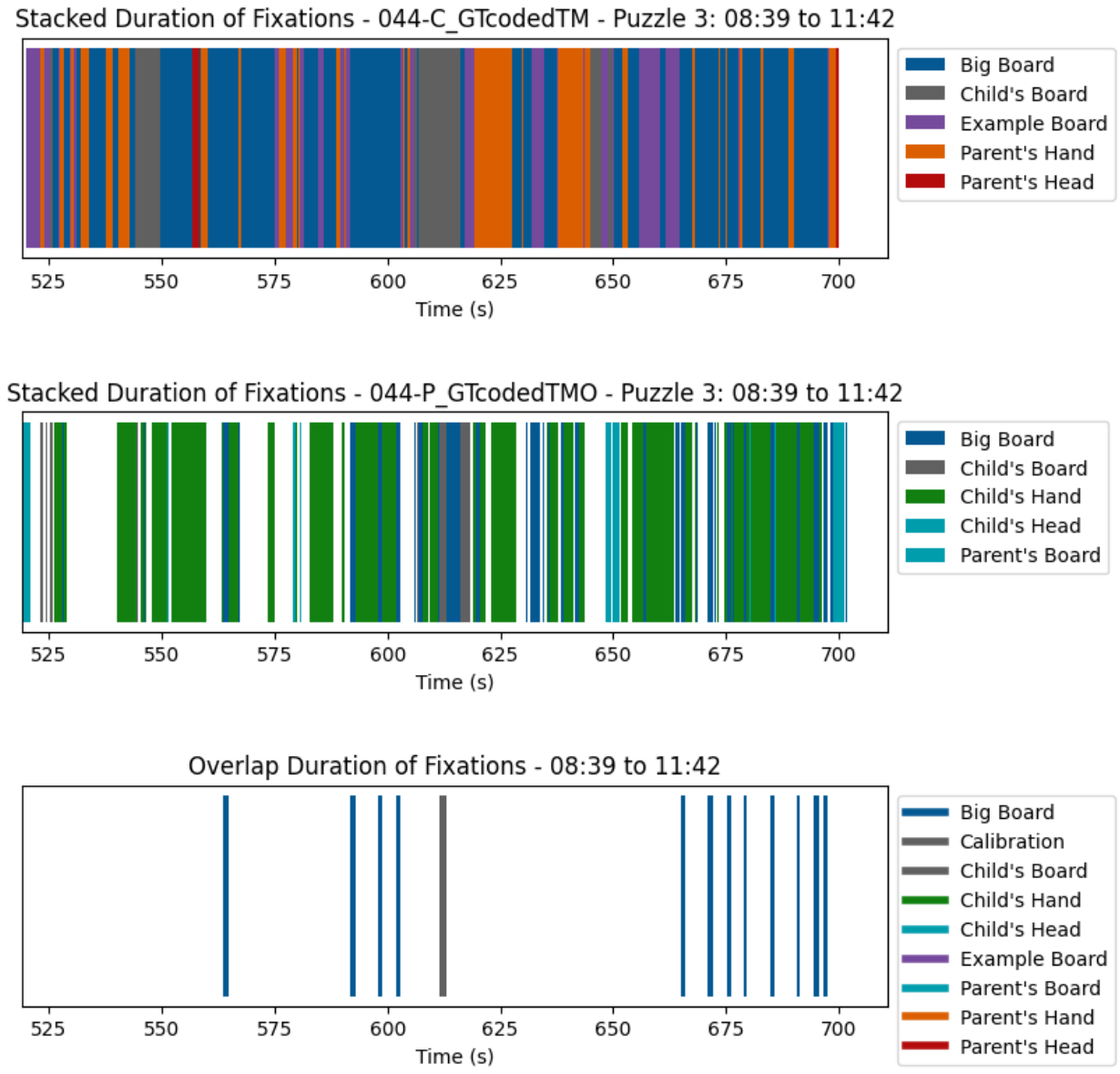
Eye-Tracking Visualization of Dyad 044 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B11.3

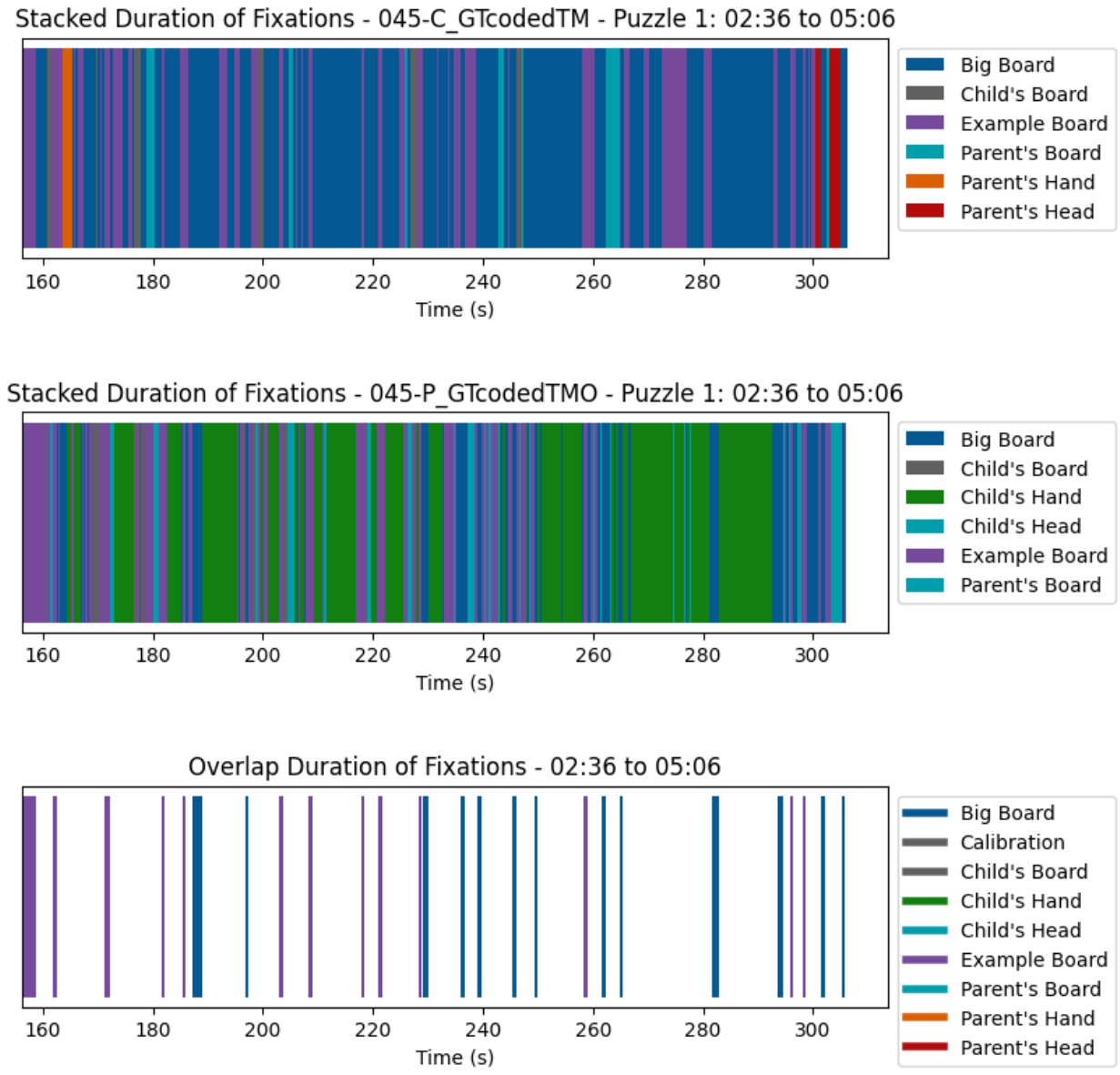
Eye-Tracking Visualization of Dyad 044 Puzzle 3



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B12.1

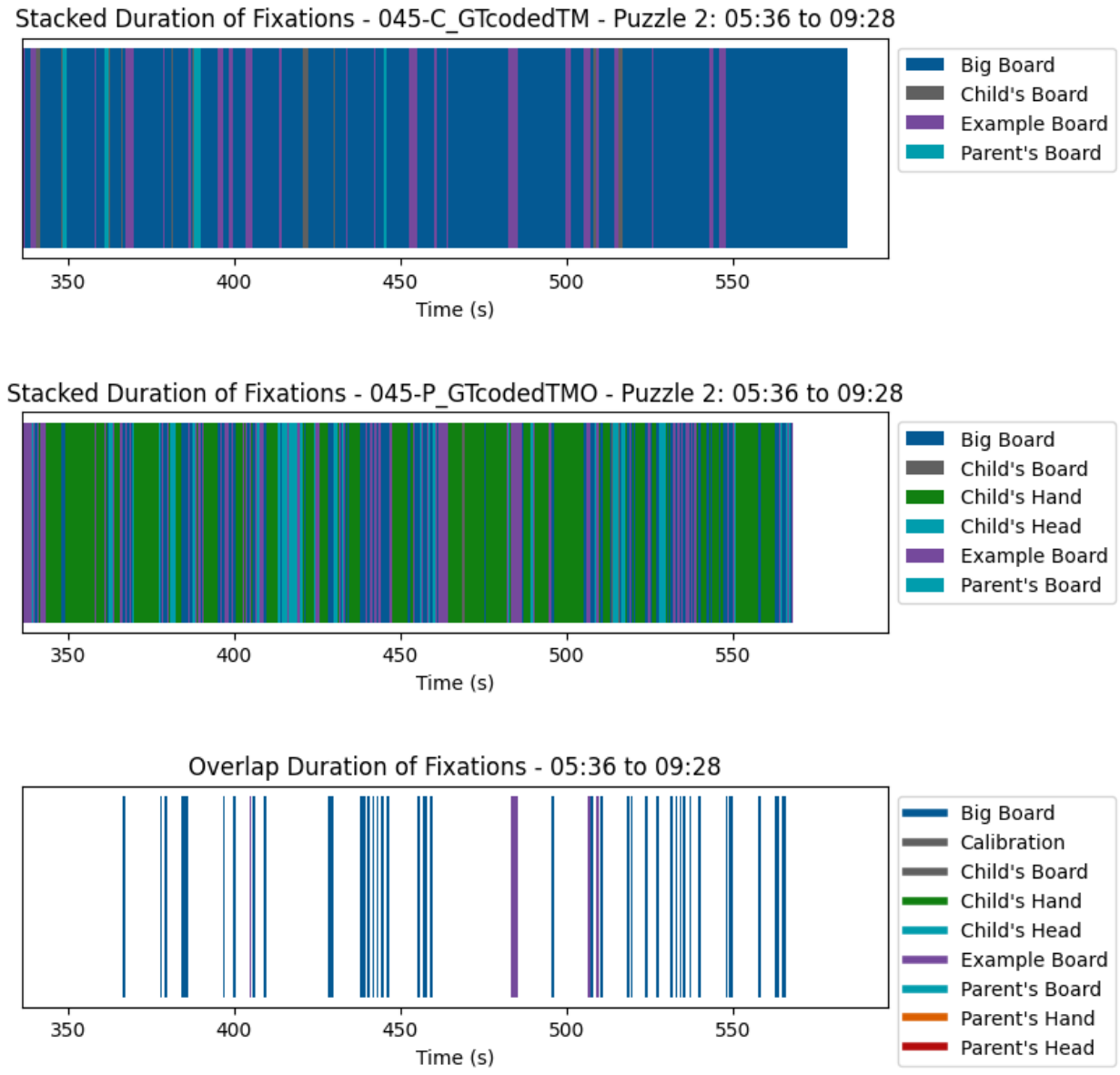
Eye-Tracking Visualization of Dyad 045 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B12.2

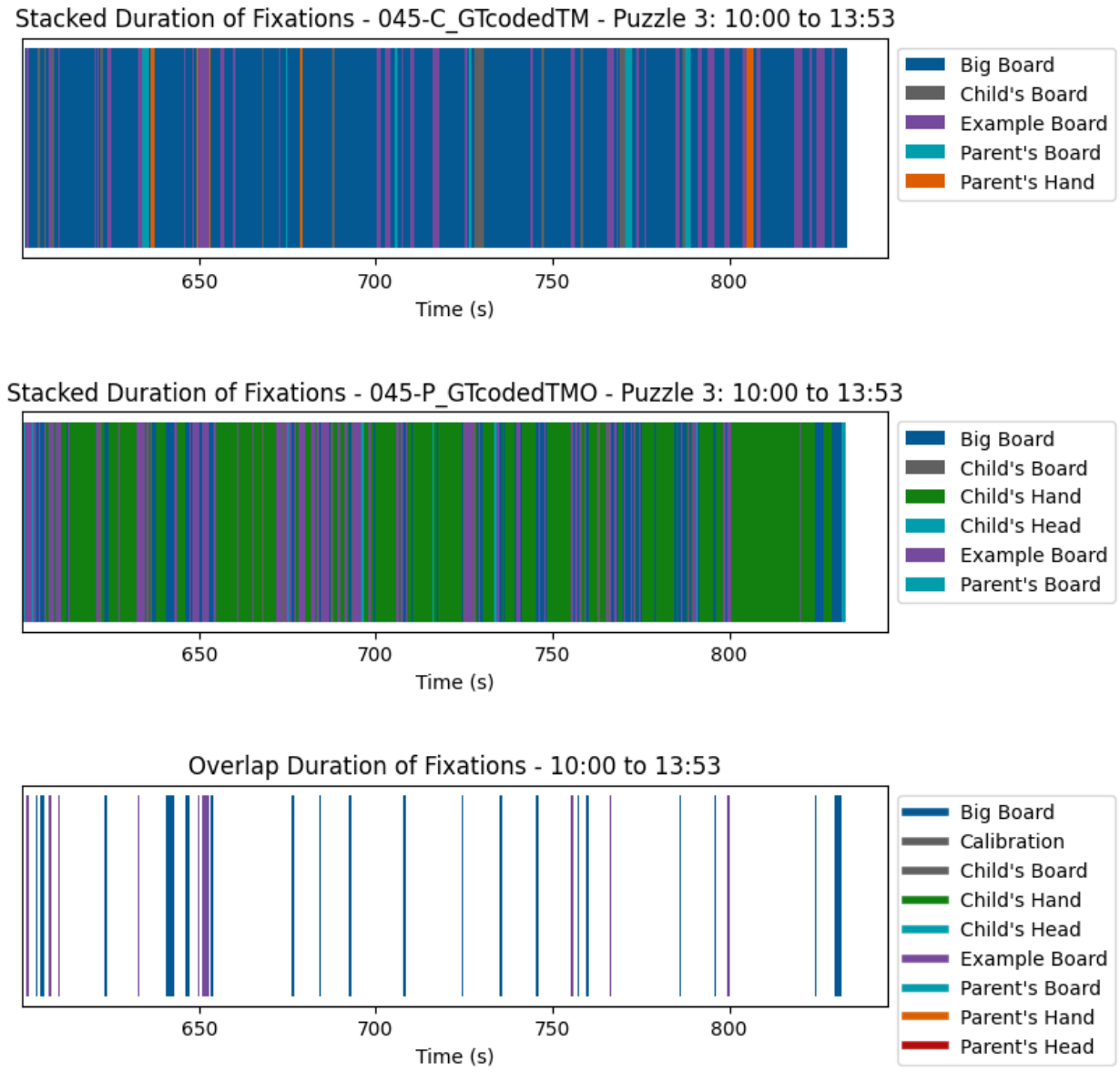
Eye-Tracking Visualization of Dyad 045 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B12.3

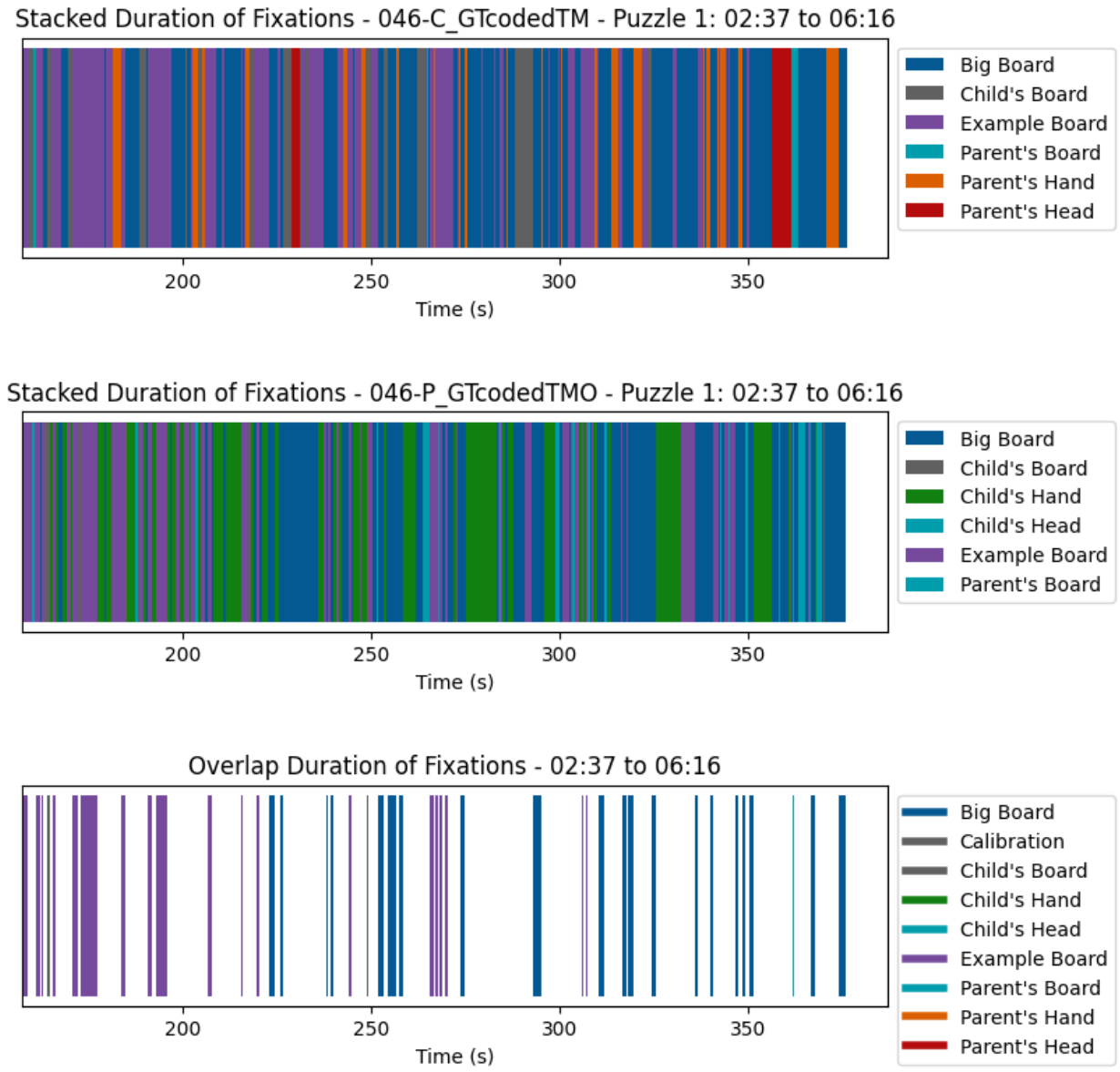
Eye-Tracking Visualization of Dyad 045 Puzzle 3



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B13.1

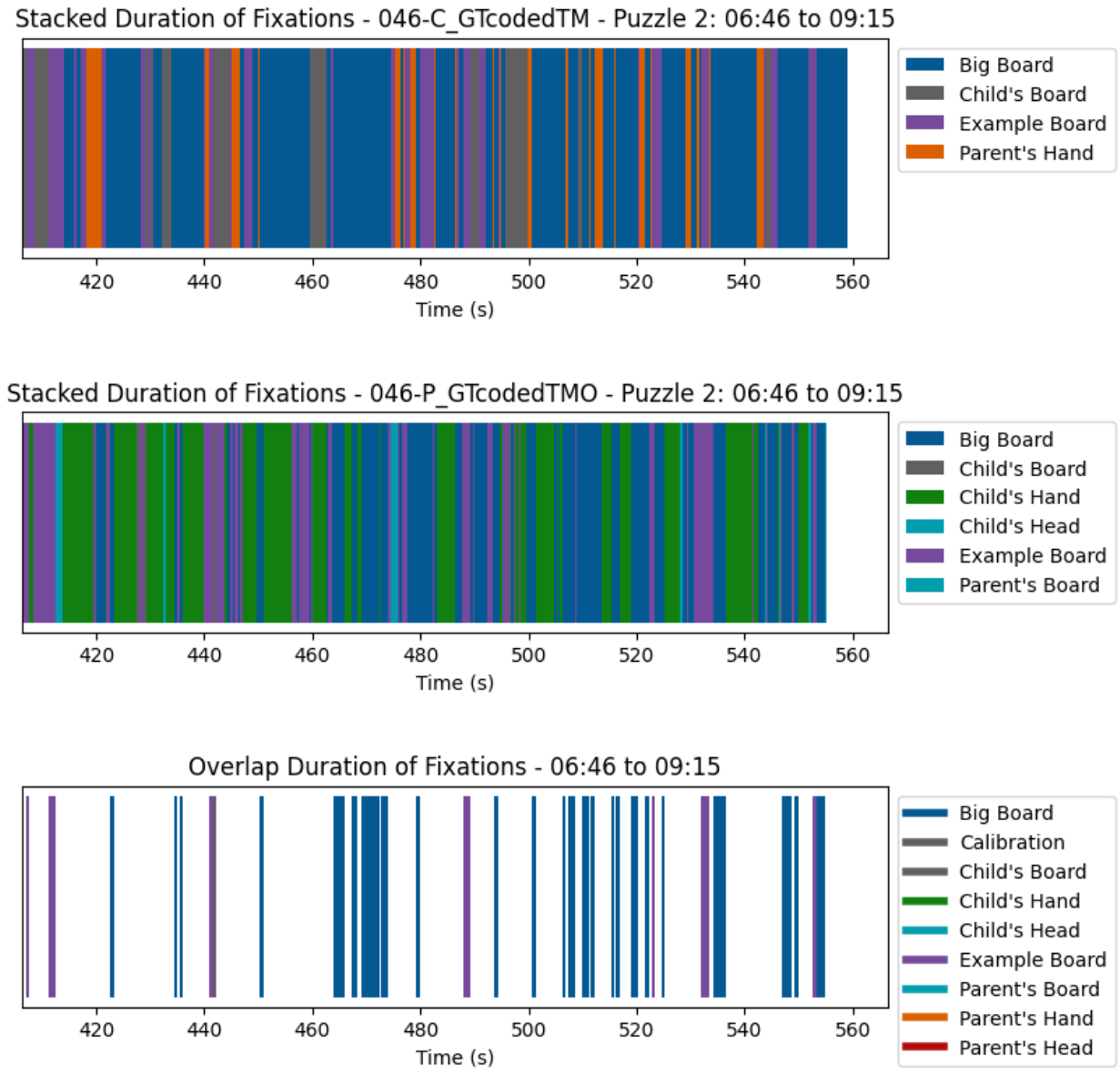
Eye-Tracking Visualization of Dyad 046 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B13.2

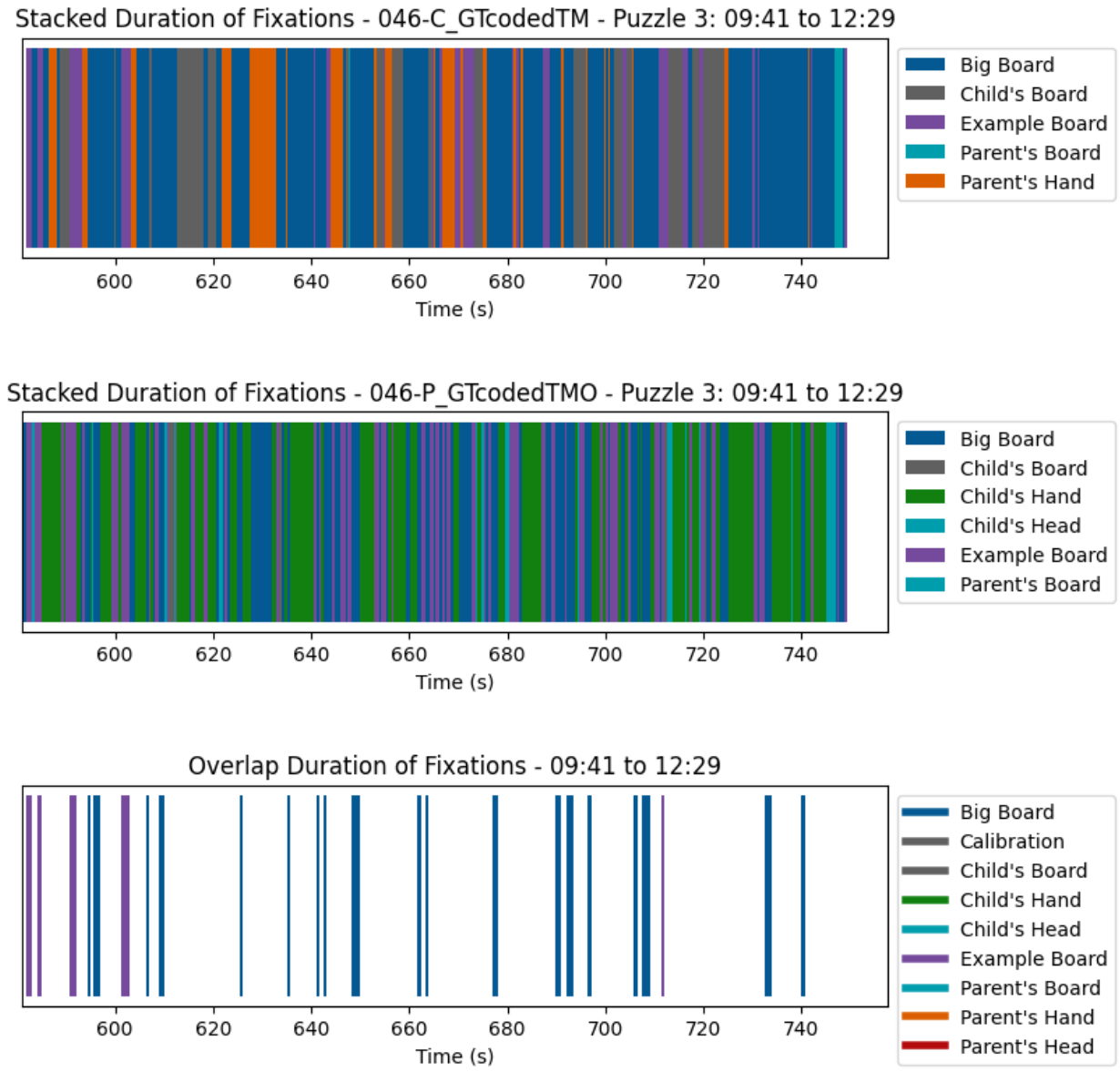
Eye-Tracking Visualization of Dyad 046 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B13.3

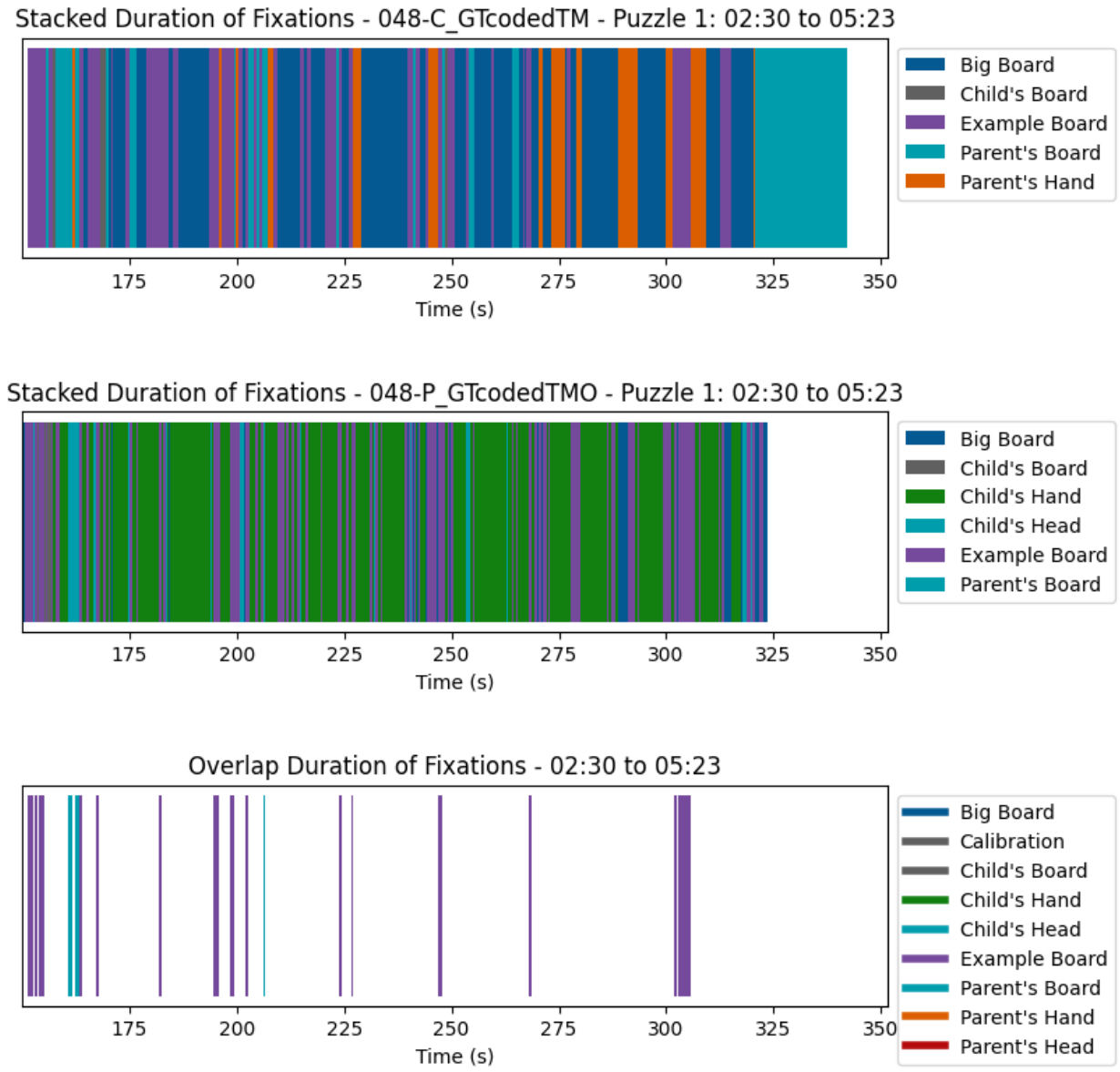
Eye-Tracking Visualization of Dyad 046 Puzzle 3



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B14.1

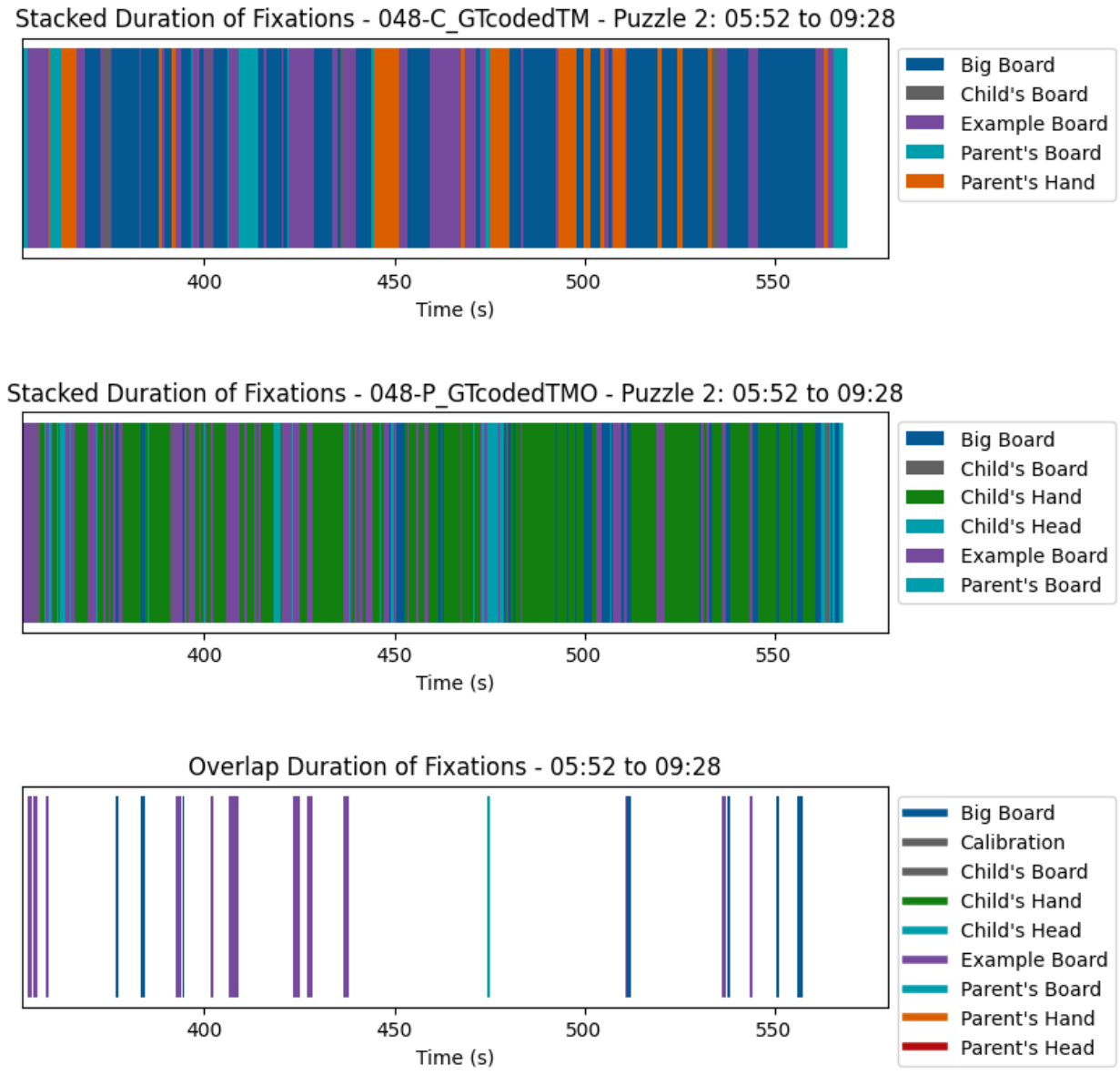
Eye-Tracking Visualization of Dyad 048 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B14.2

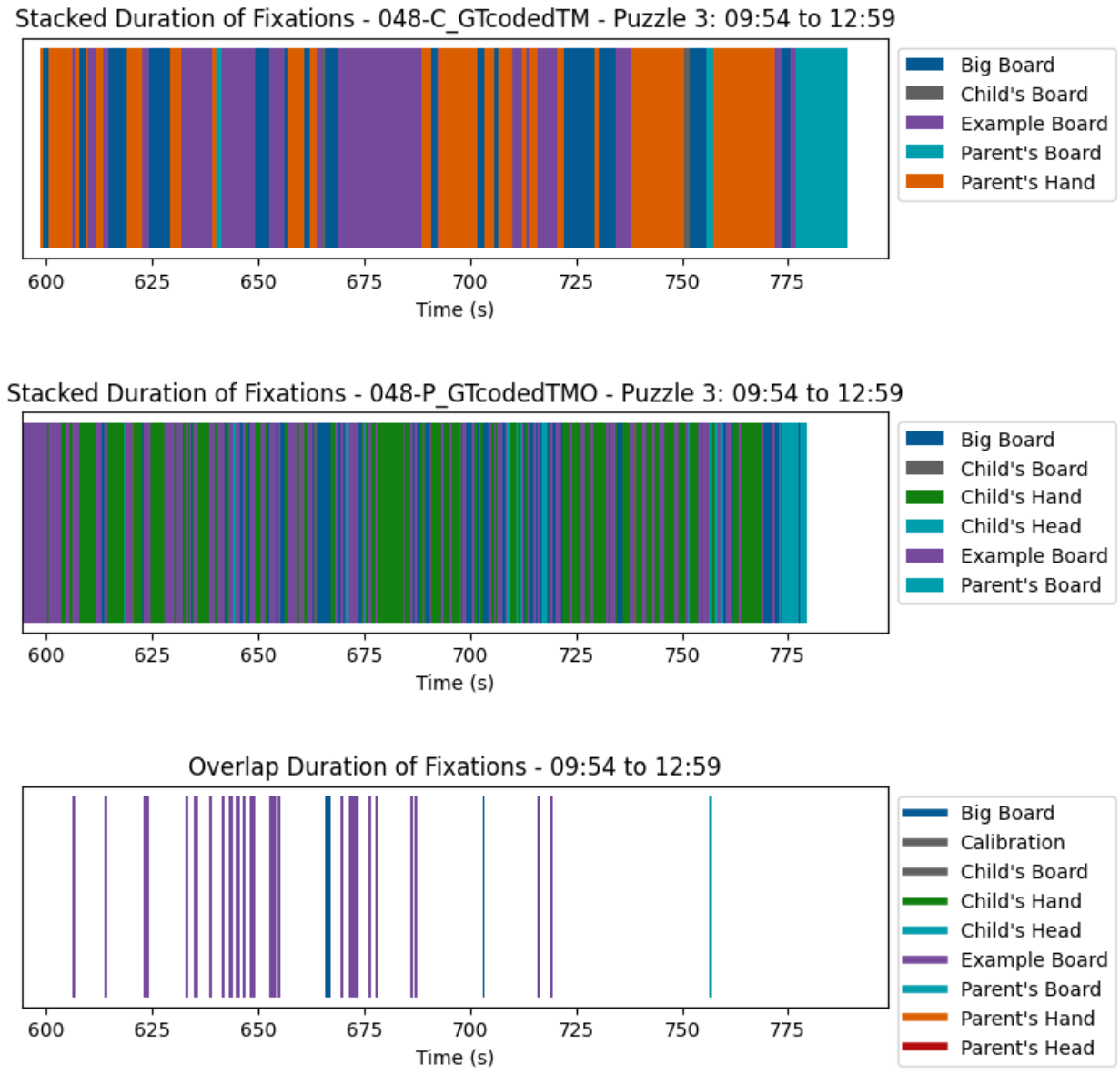
Eye-Tracking Visualization of Dyad 048 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B14.3

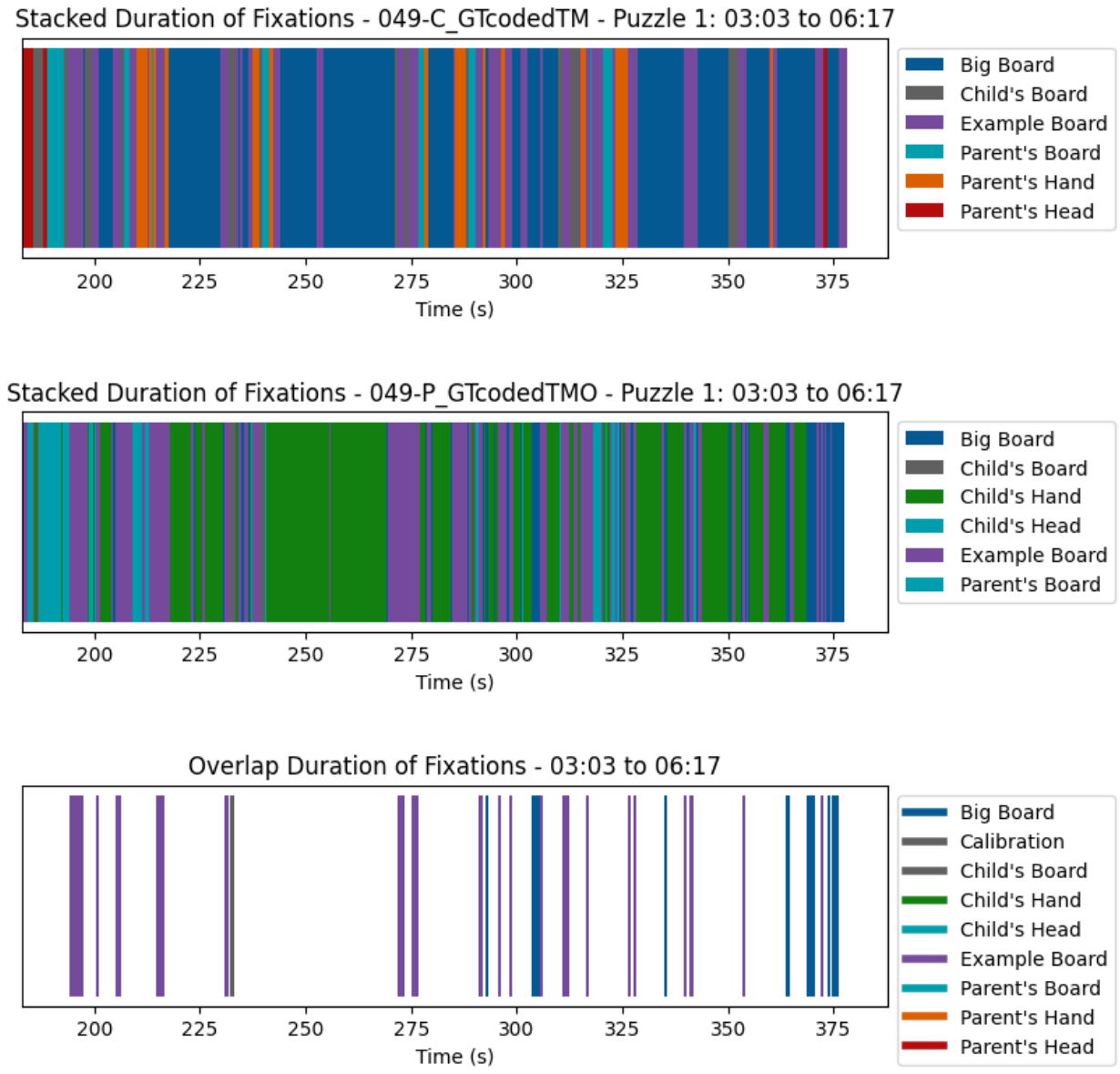
Eye-Tracking Visualization of Dyad 048 Puzzle 3



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B15.1

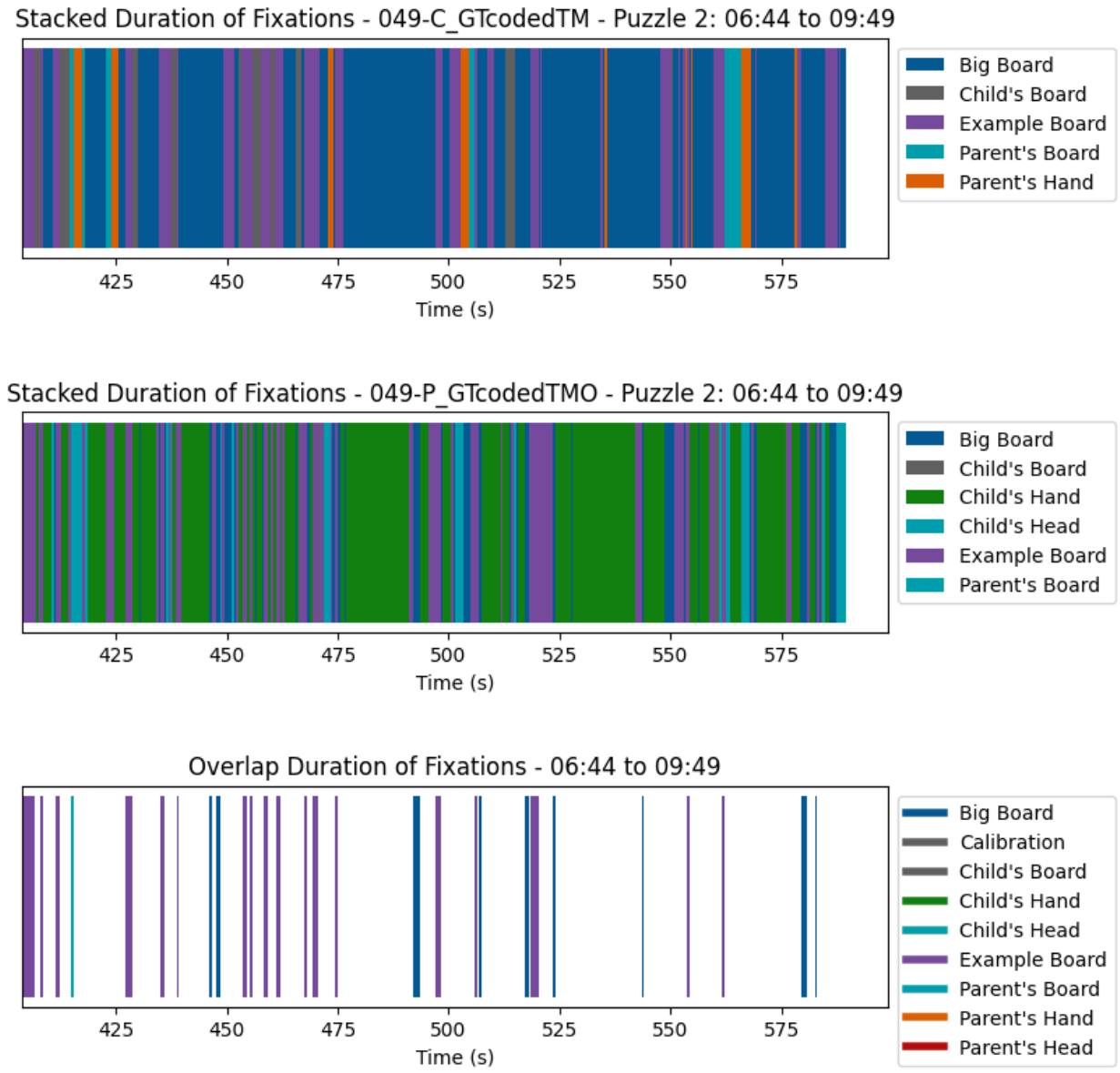
Eye-Tracking Visualization of Dyad 049 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B15.2

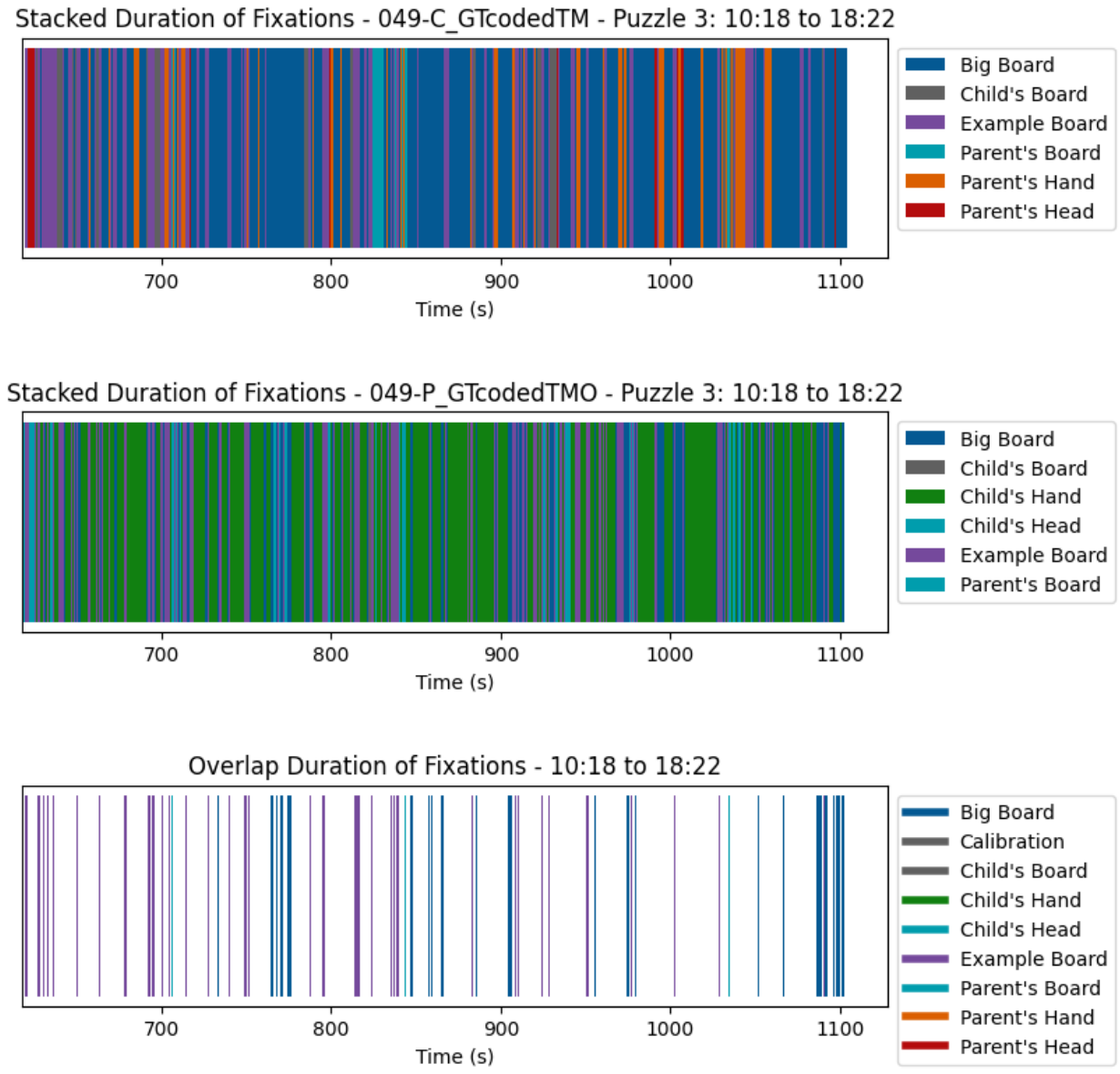
Eye-Tracking Visualization of Dyad 049 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B15.3

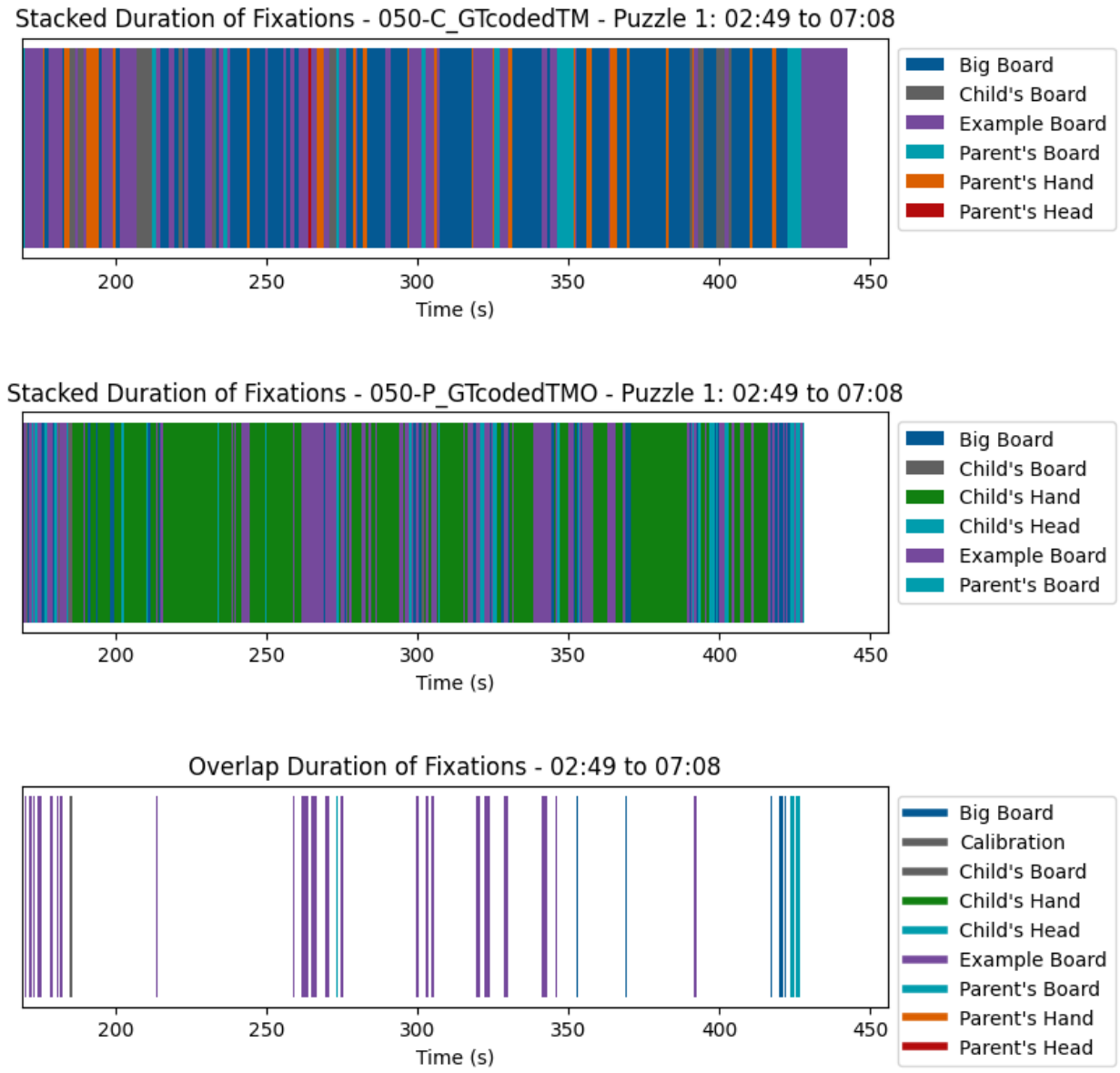
Eye-Tracking Visualization of Dyad 049 Puzzle 3



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B16.1

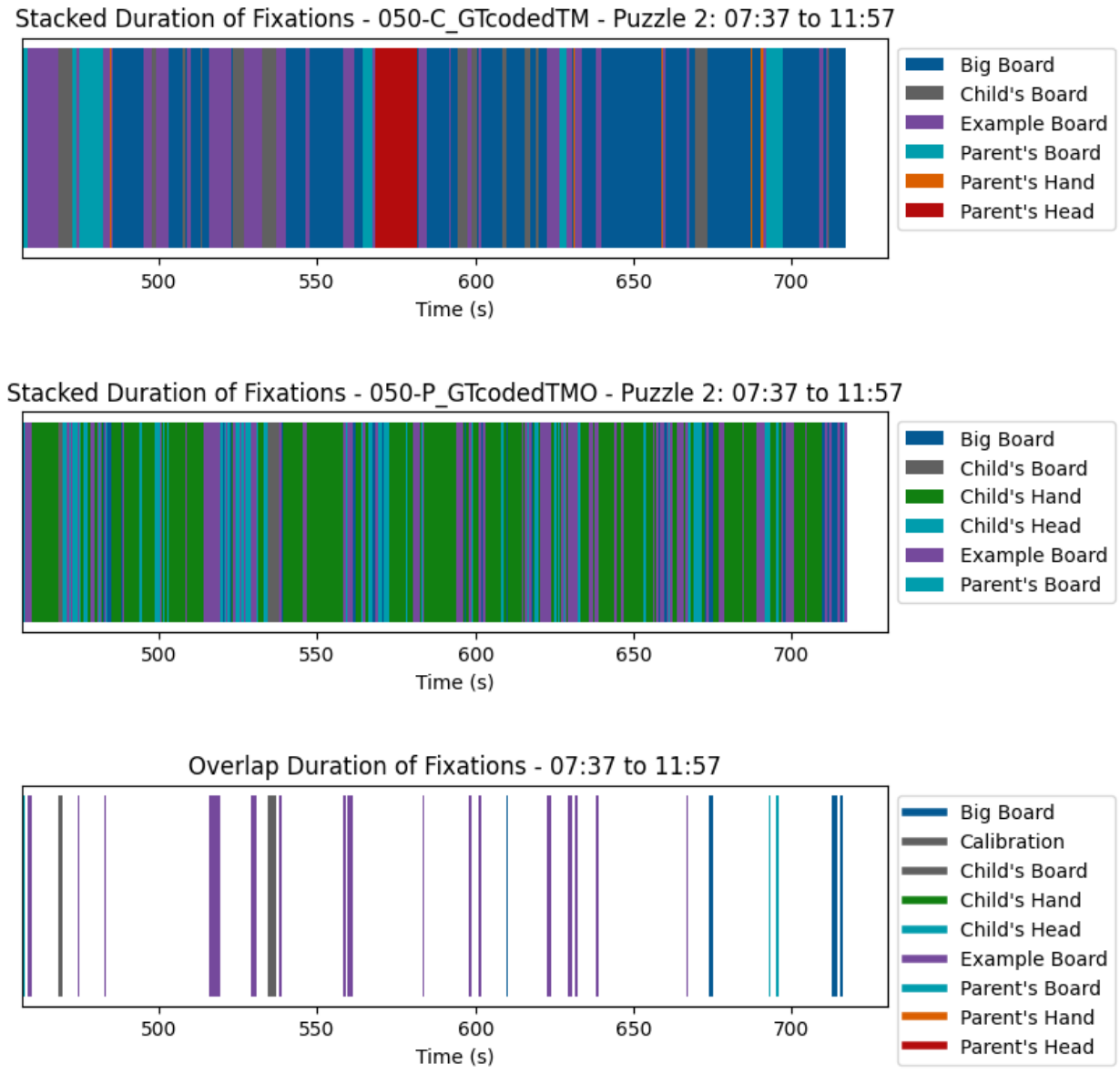
Eye-Tracking Visualization of Dyad 050 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B16.2

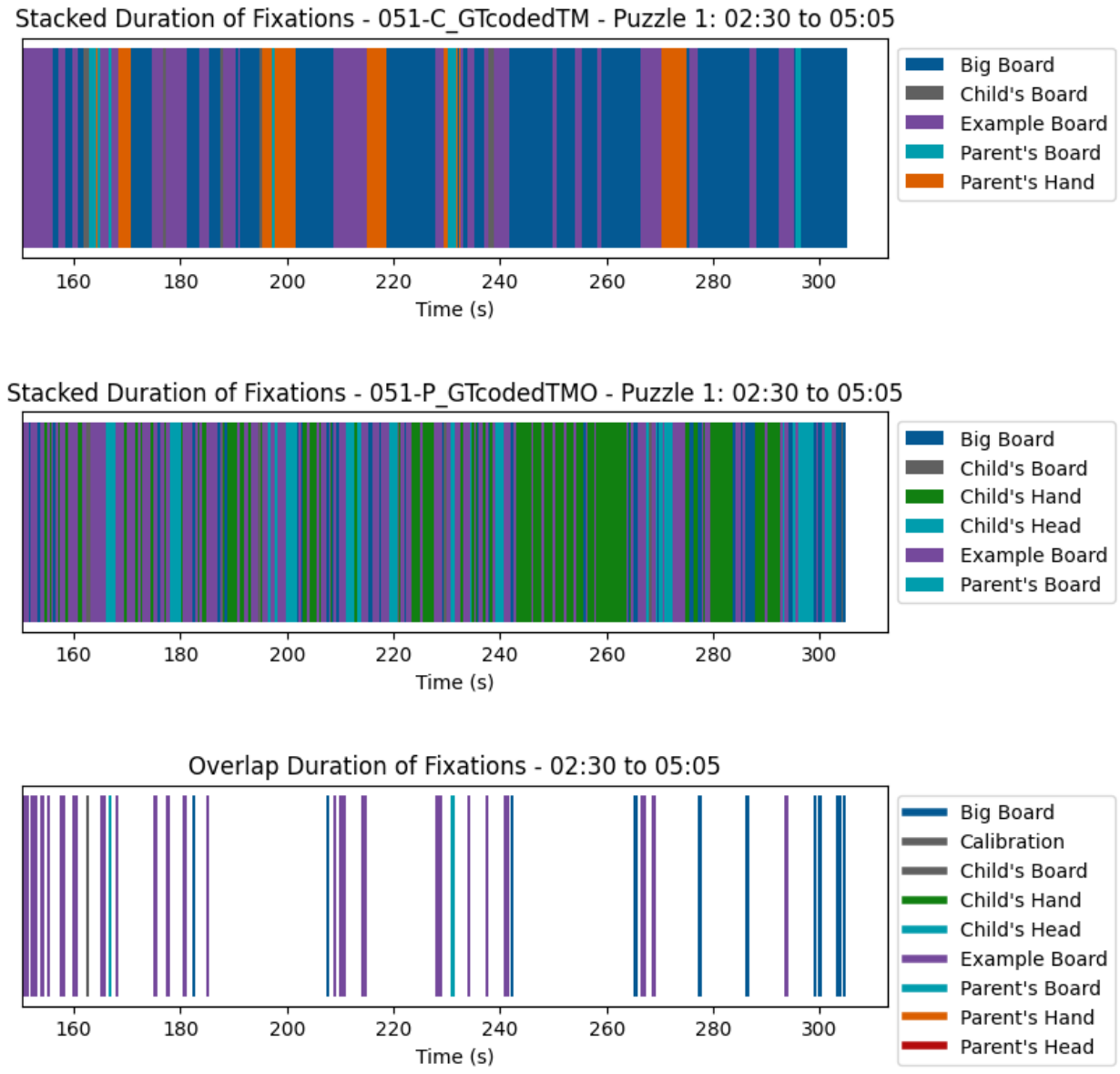
Eye-Tracking Visualization of Dyad 050 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B17.1

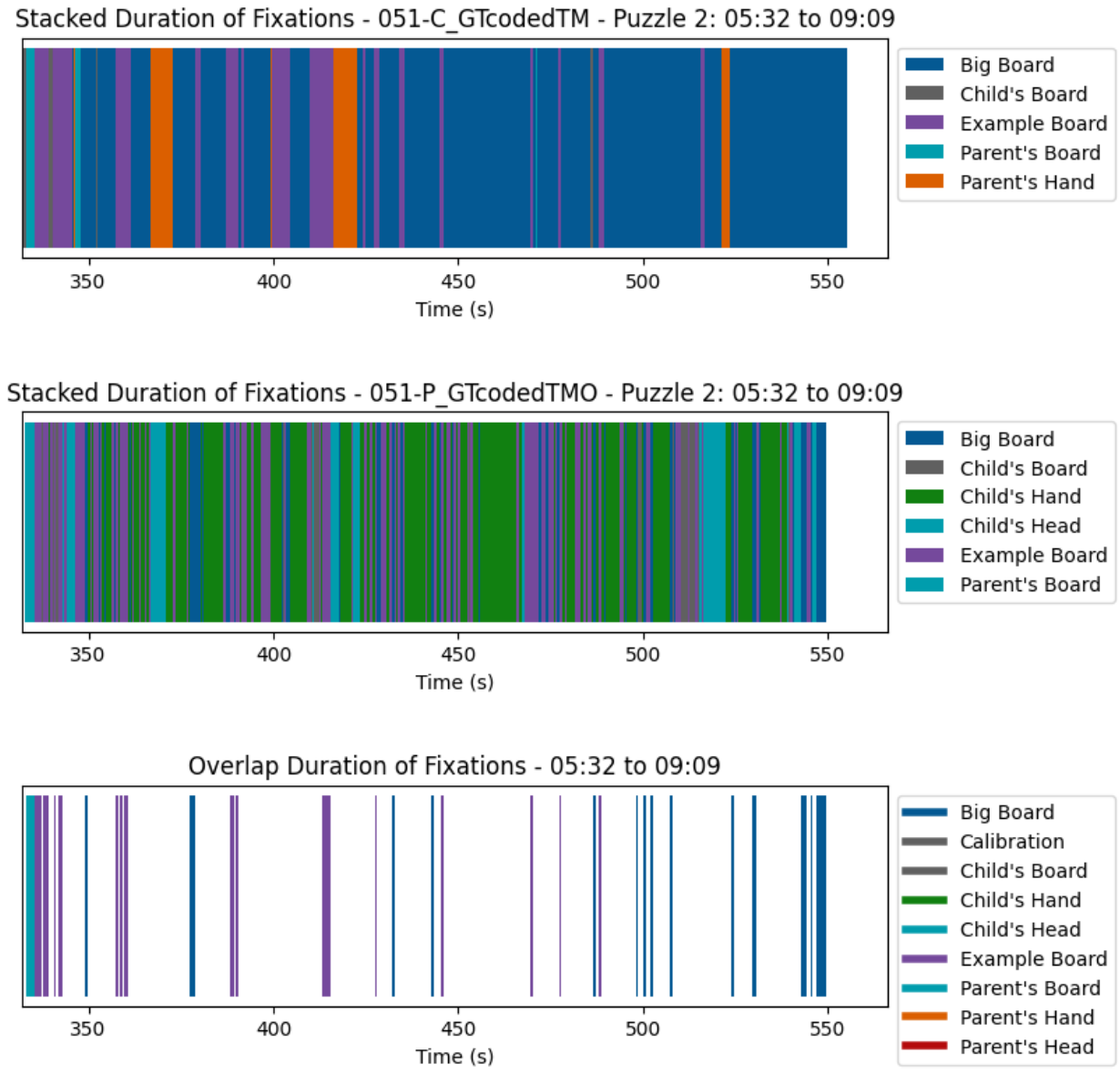
Eye-Tracking Visualization of Dyad 051 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B17.2

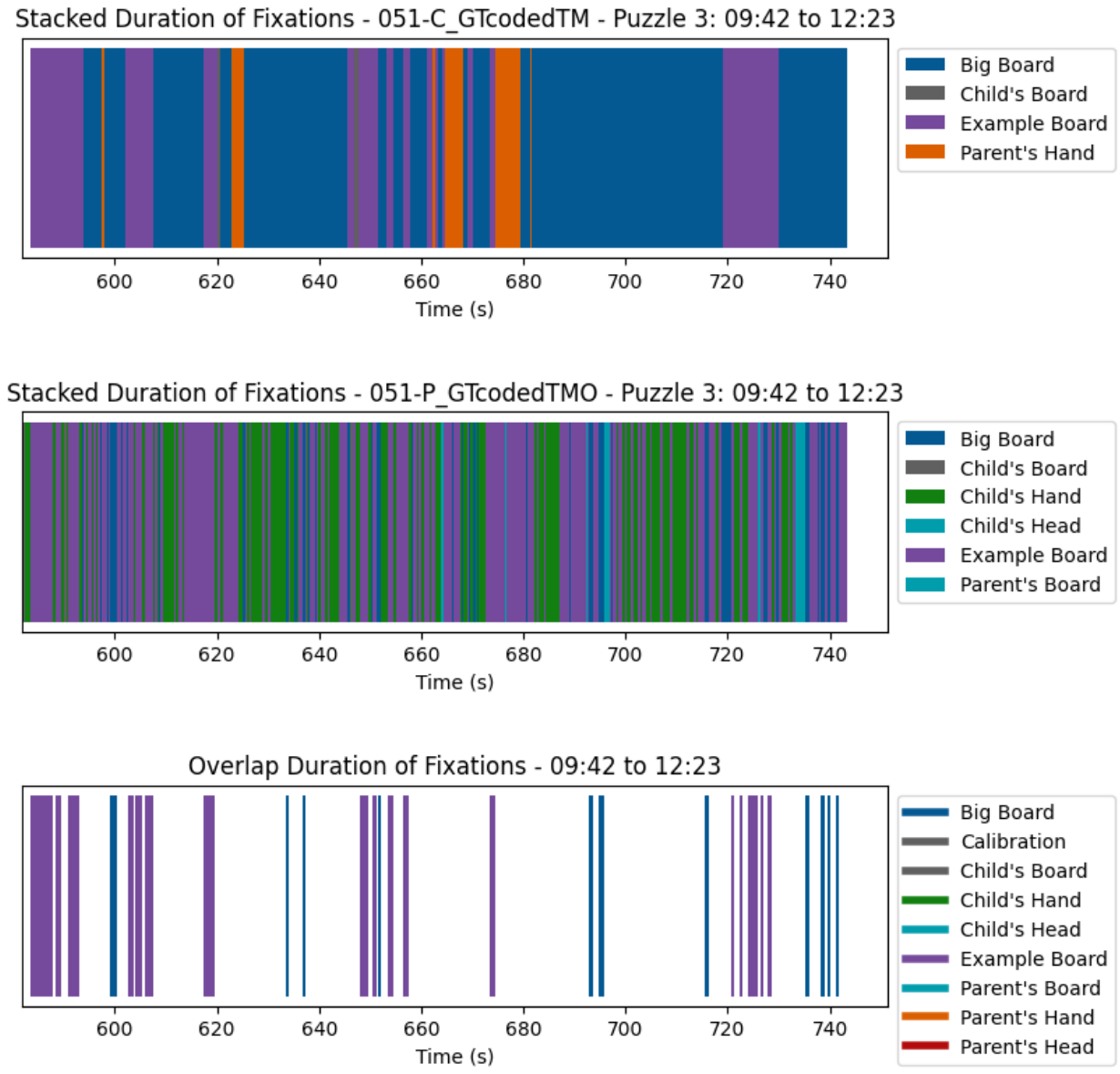
Eye-Tracking Visualization of Dyad 051 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B17.3

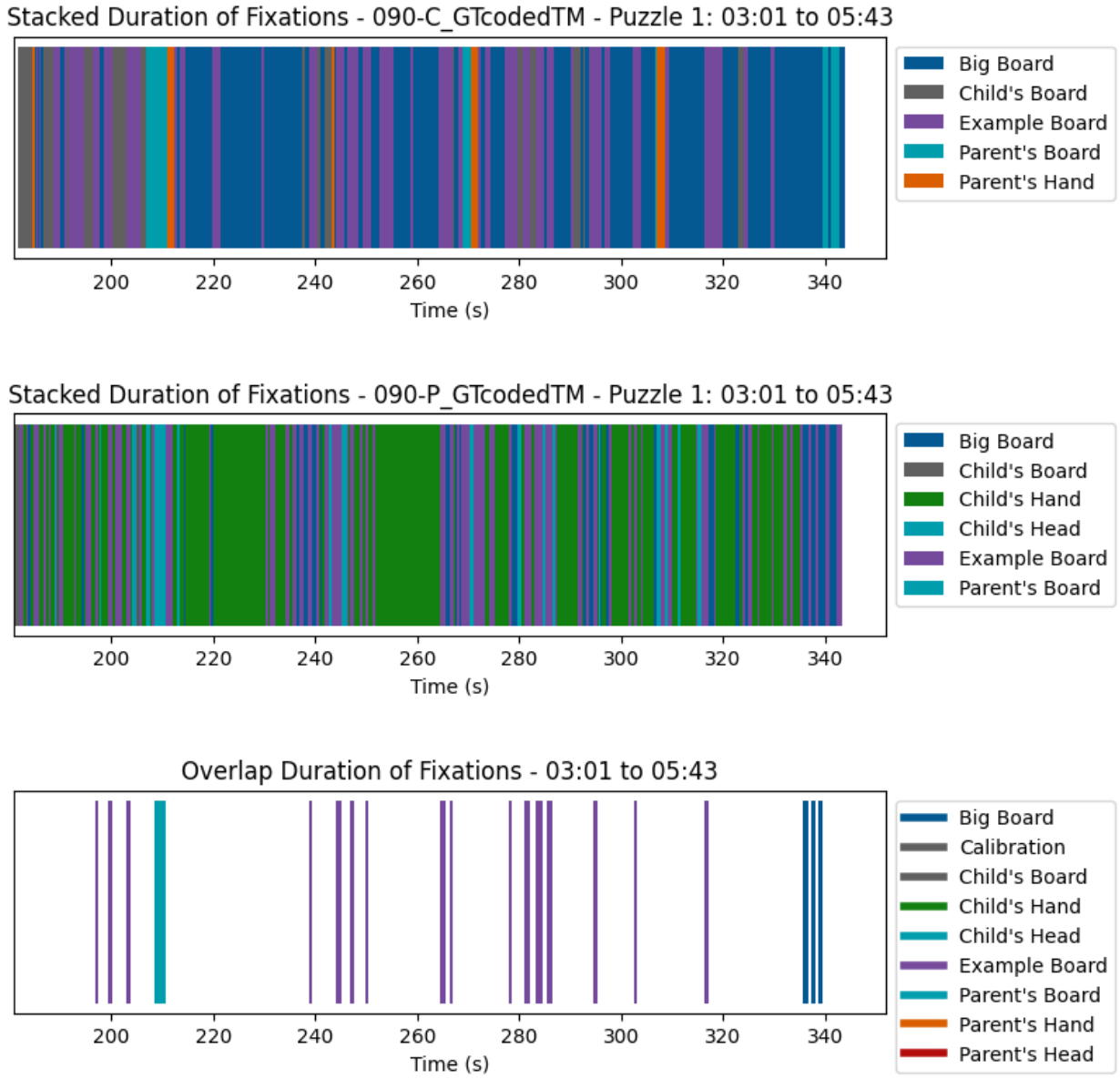
Eye-Tracking Visualization of Dyad 051 Puzzle 3



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B18.1

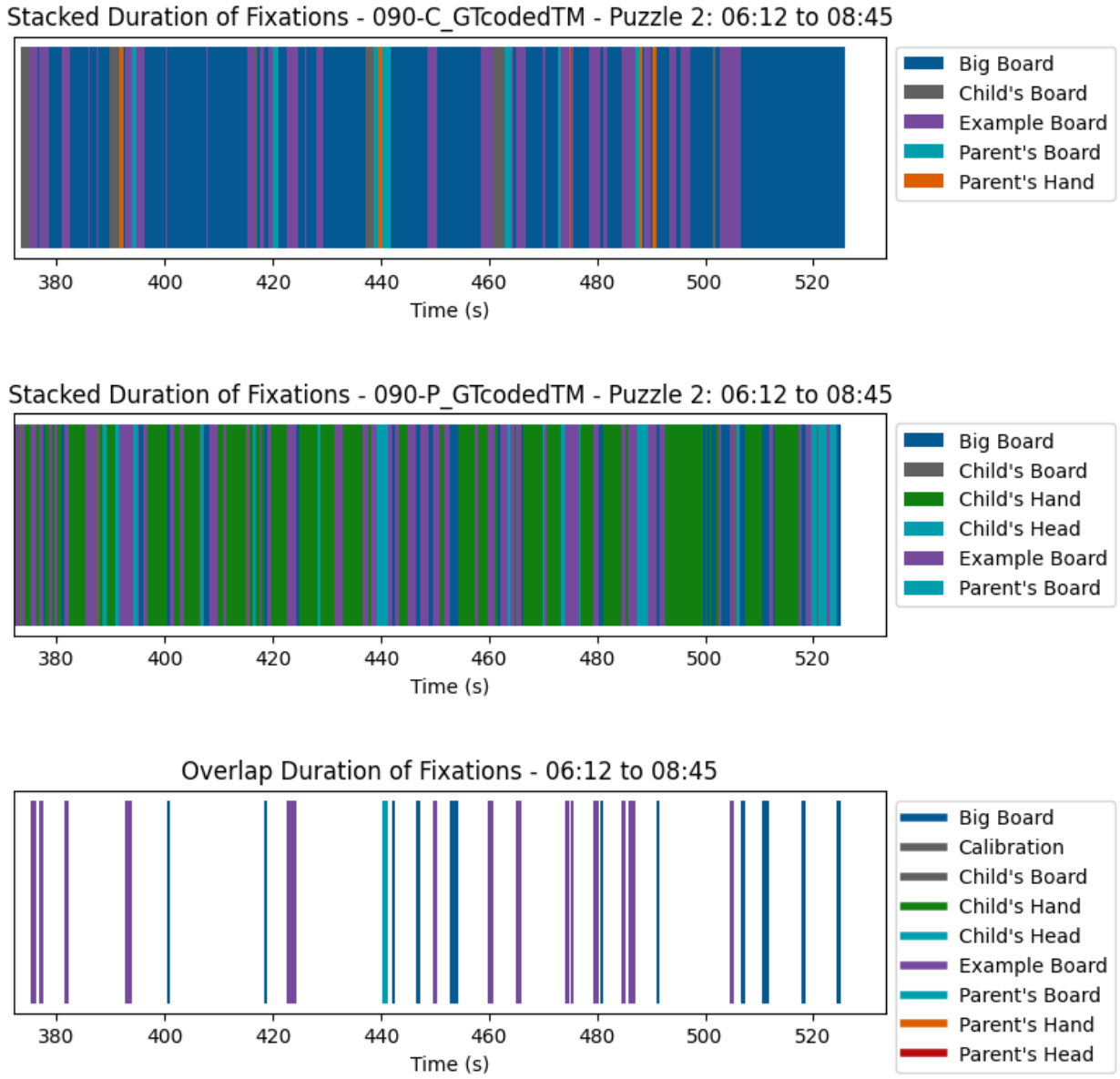
Eye-Tracking Visualization of Dyad 090 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B18.2

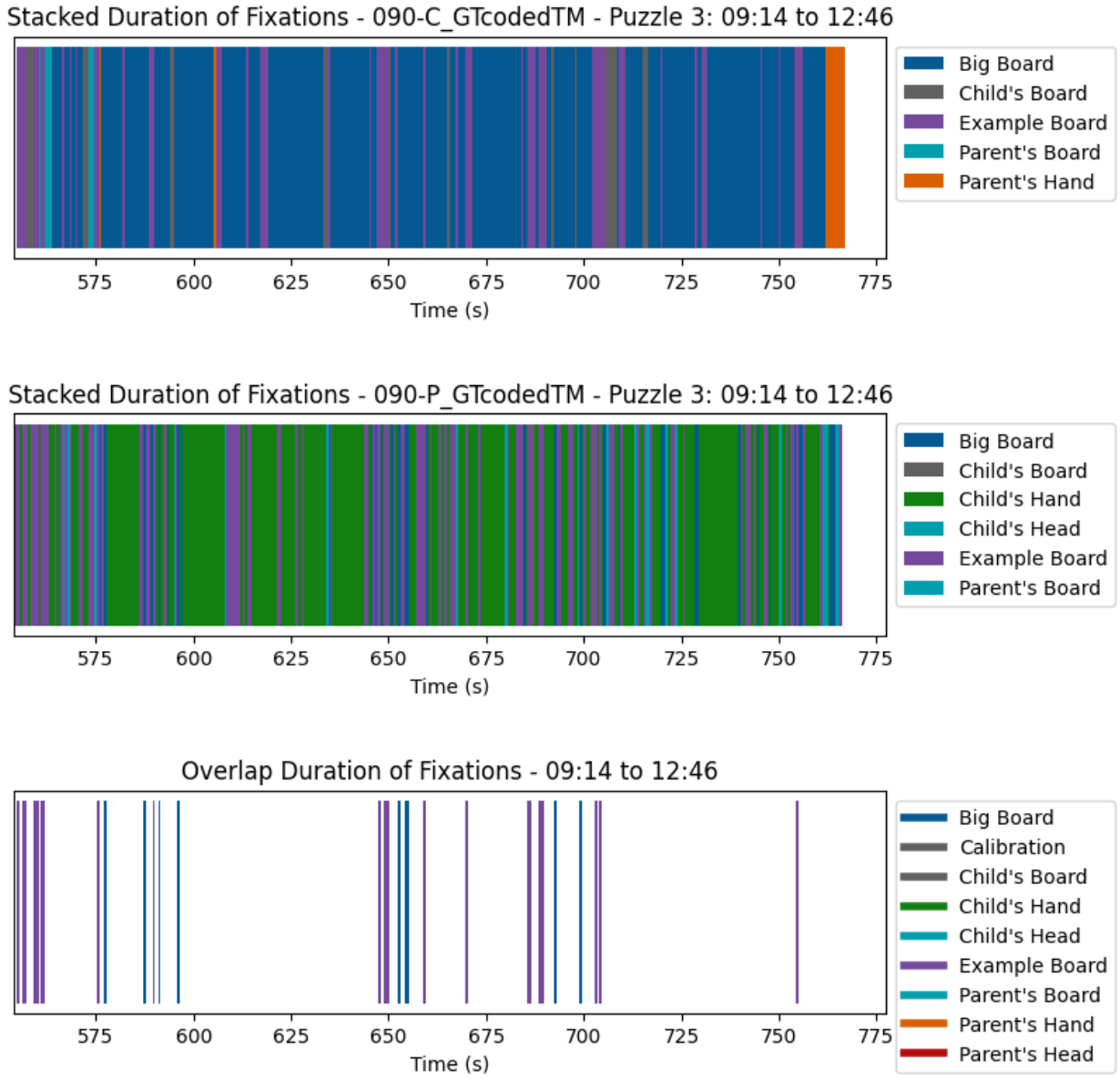
Eye-Tracking Visualization of Dyad 090 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B18.3

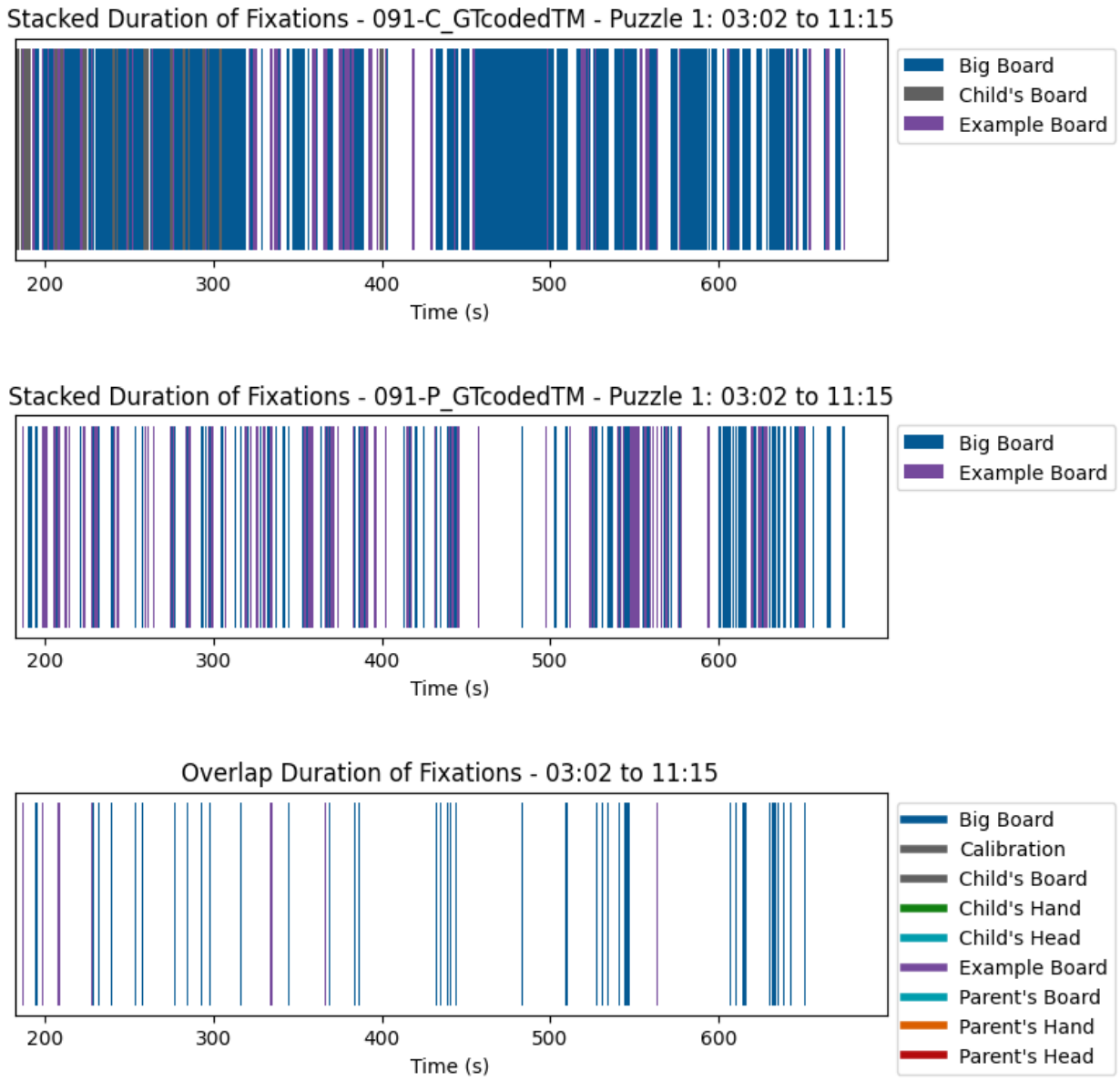
Eye-Tracking Visualization of Dyad 090 Puzzle 3



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B19.1

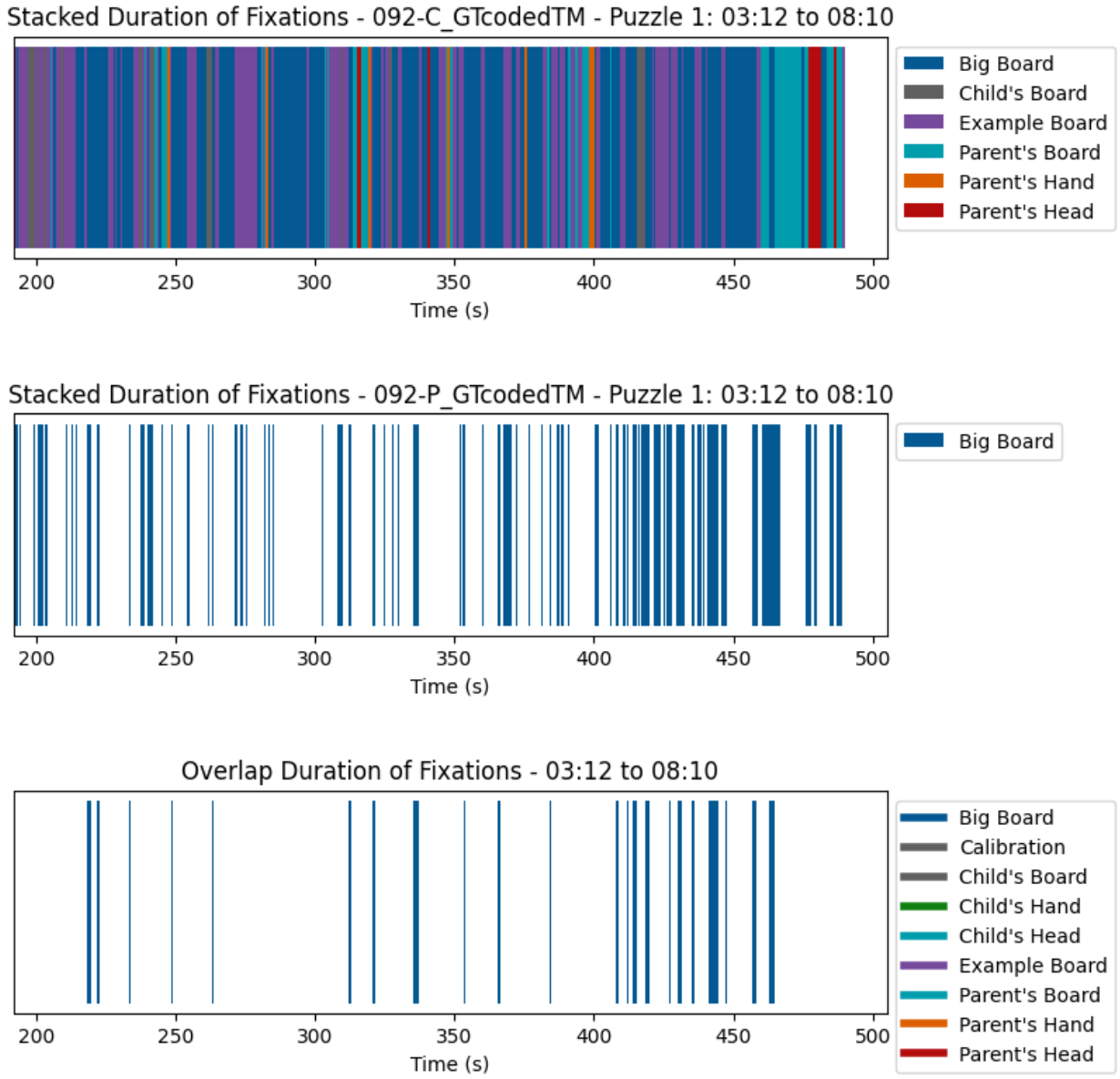
Eye-Tracking Visualization of Dyad 091 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B20.1

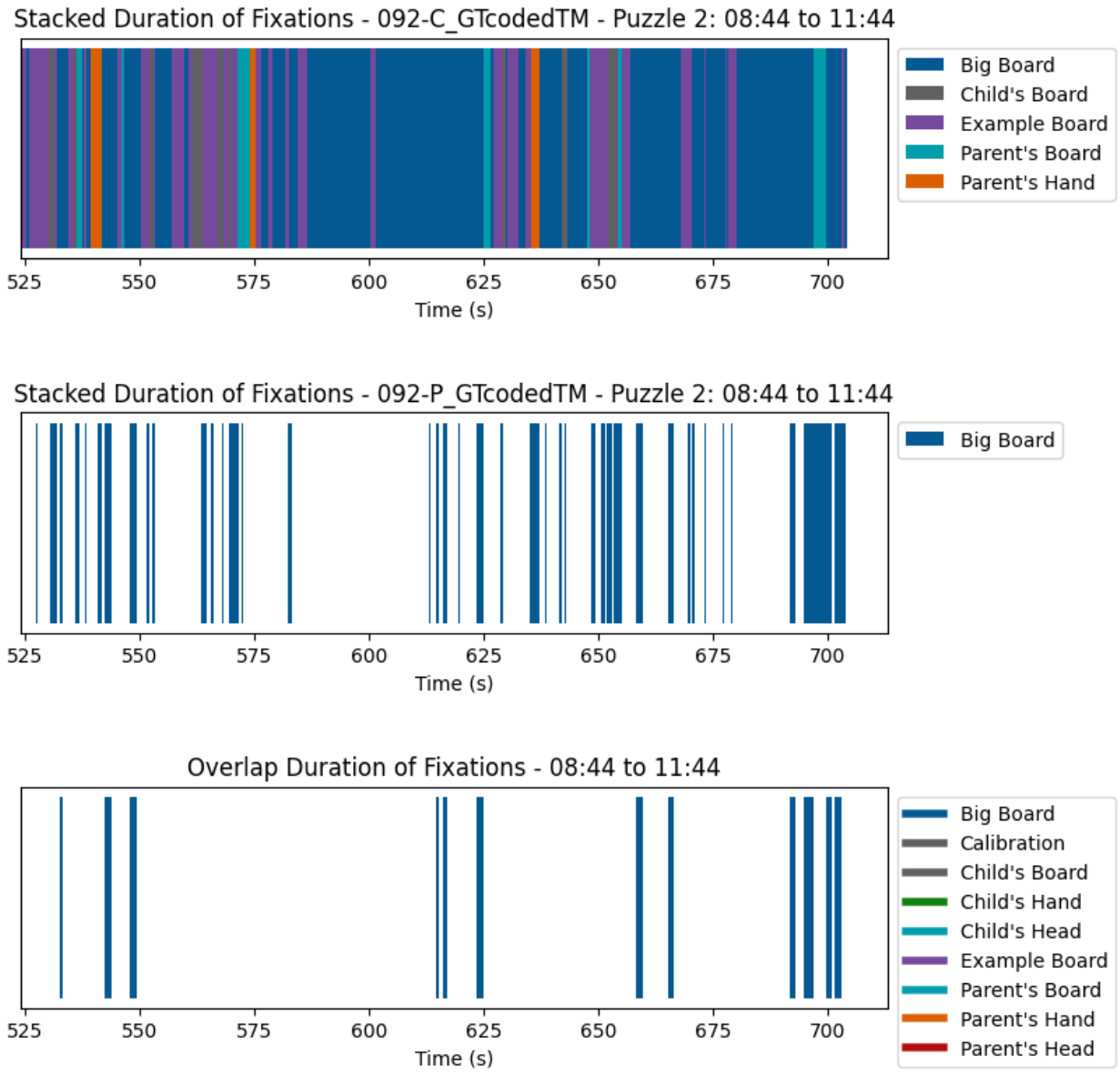
Eye-Tracking Visualization of Dyad 092 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B20.2

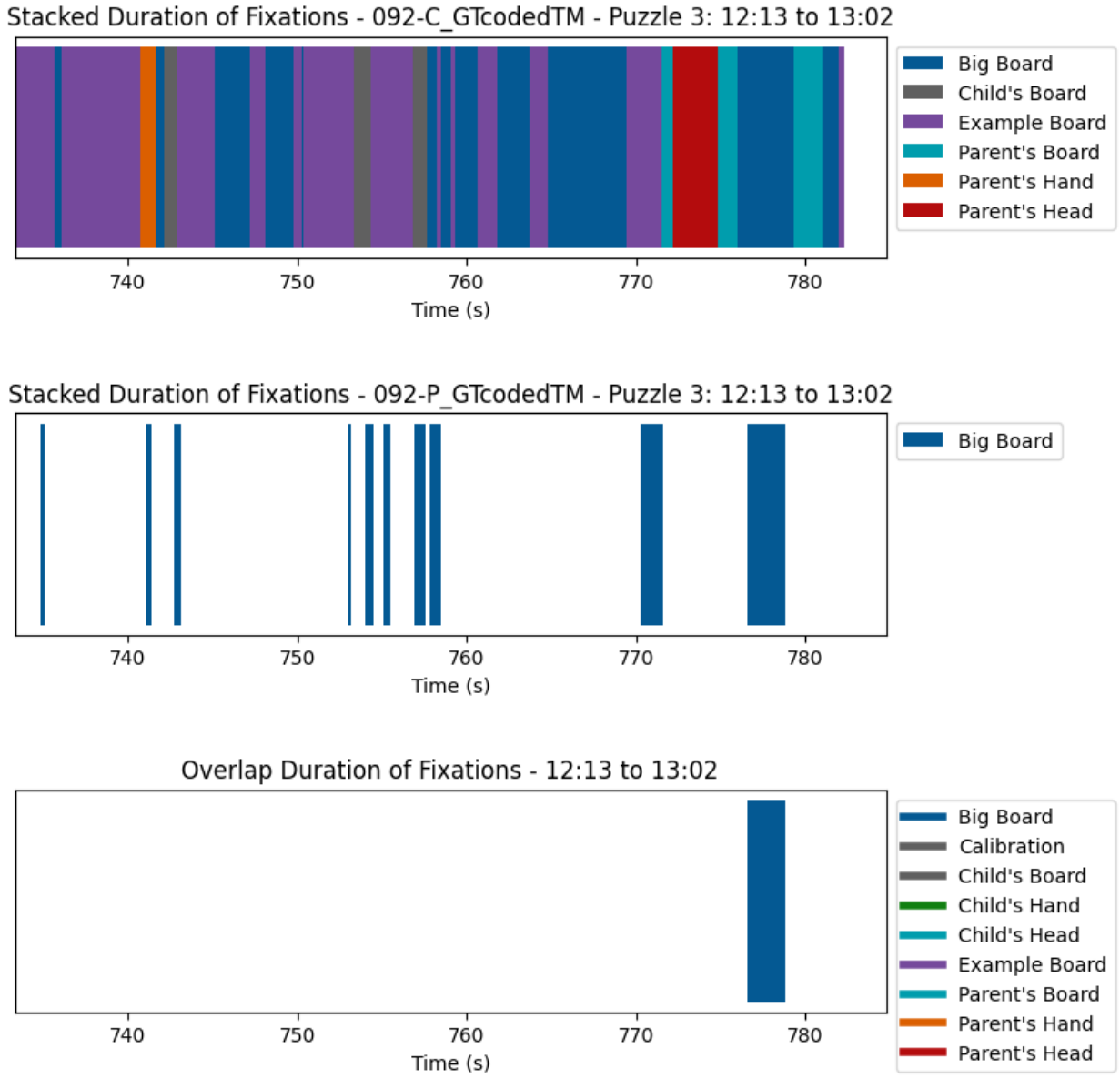
Eye-Tracking Visualization of Dyad 092 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B20.3

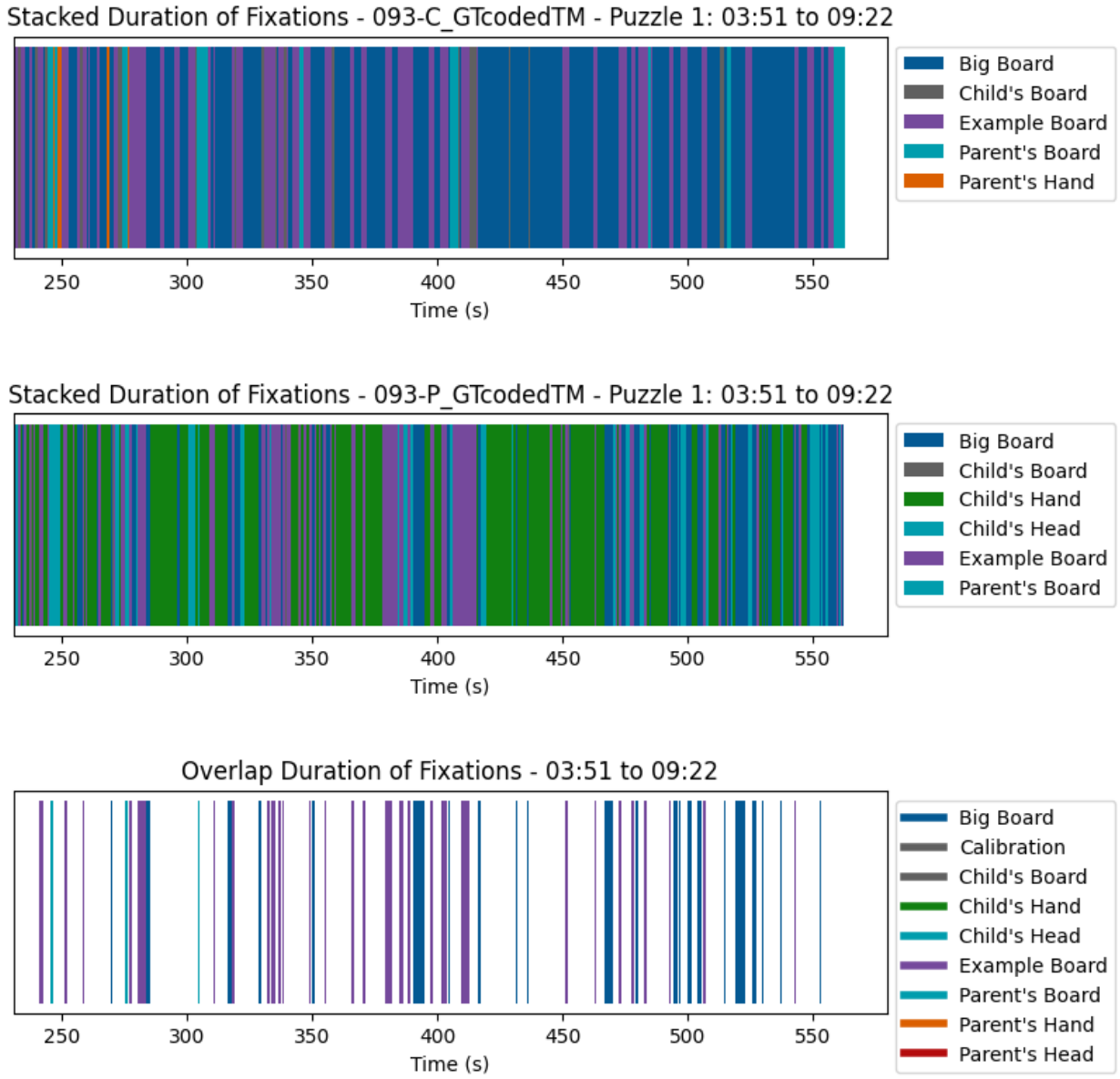
Eye-Tracking Visualization of Dyad 092 Puzzle 3



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B21.1

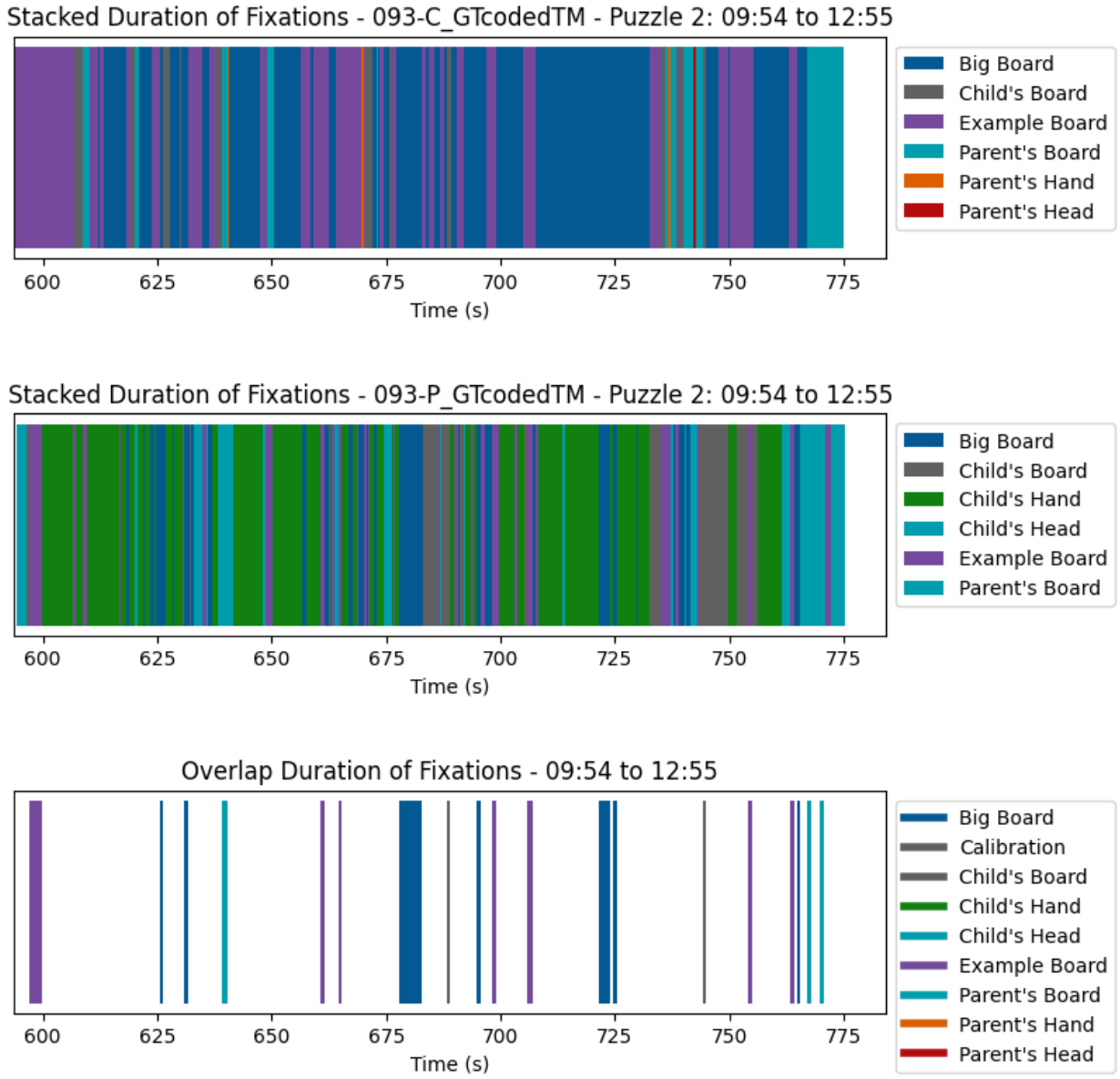
Eye-Tracking Visualization of Dyad 093 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B21.2

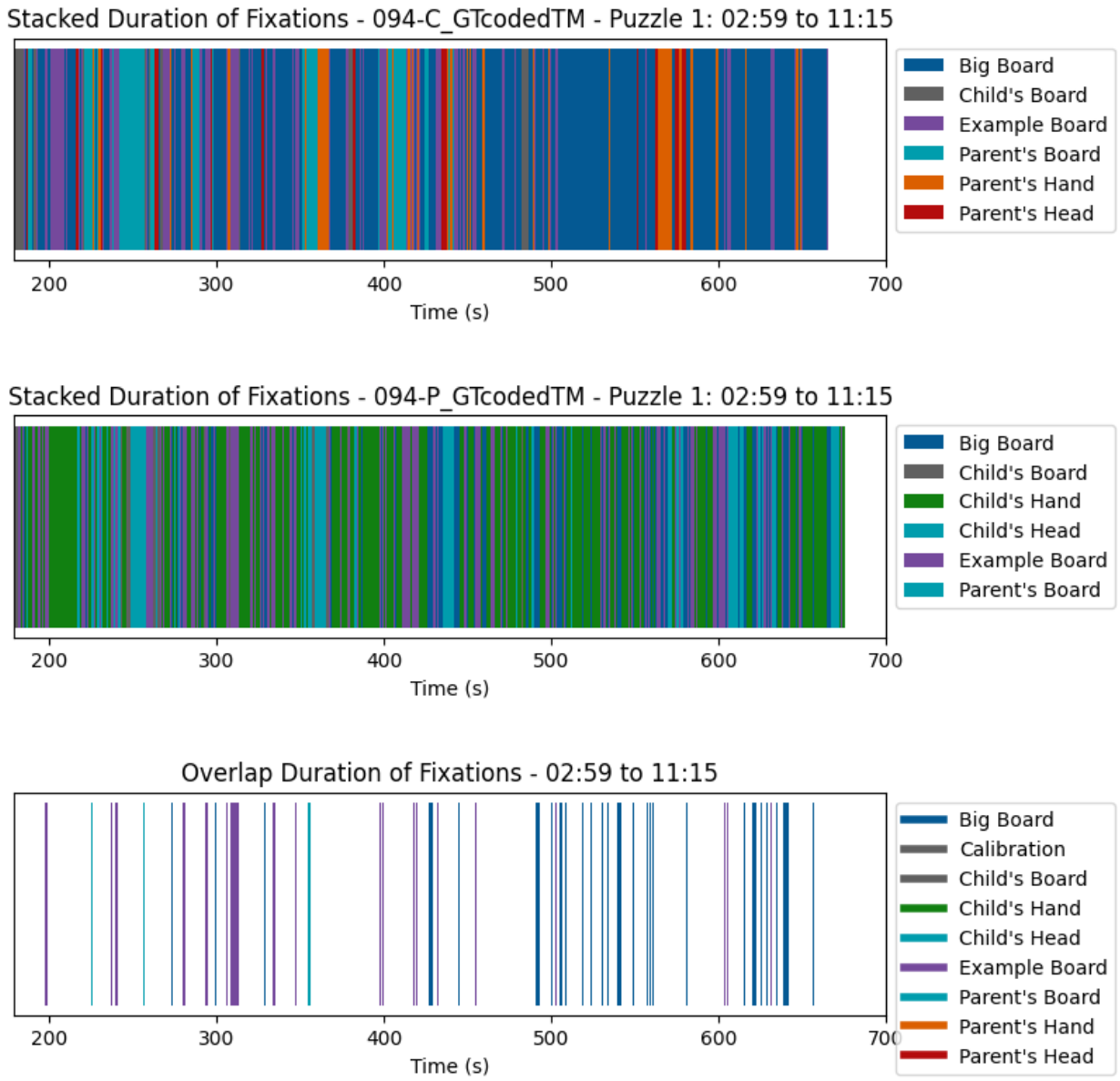
Eye-Tracking Visualization of Dyad 093 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B22.1

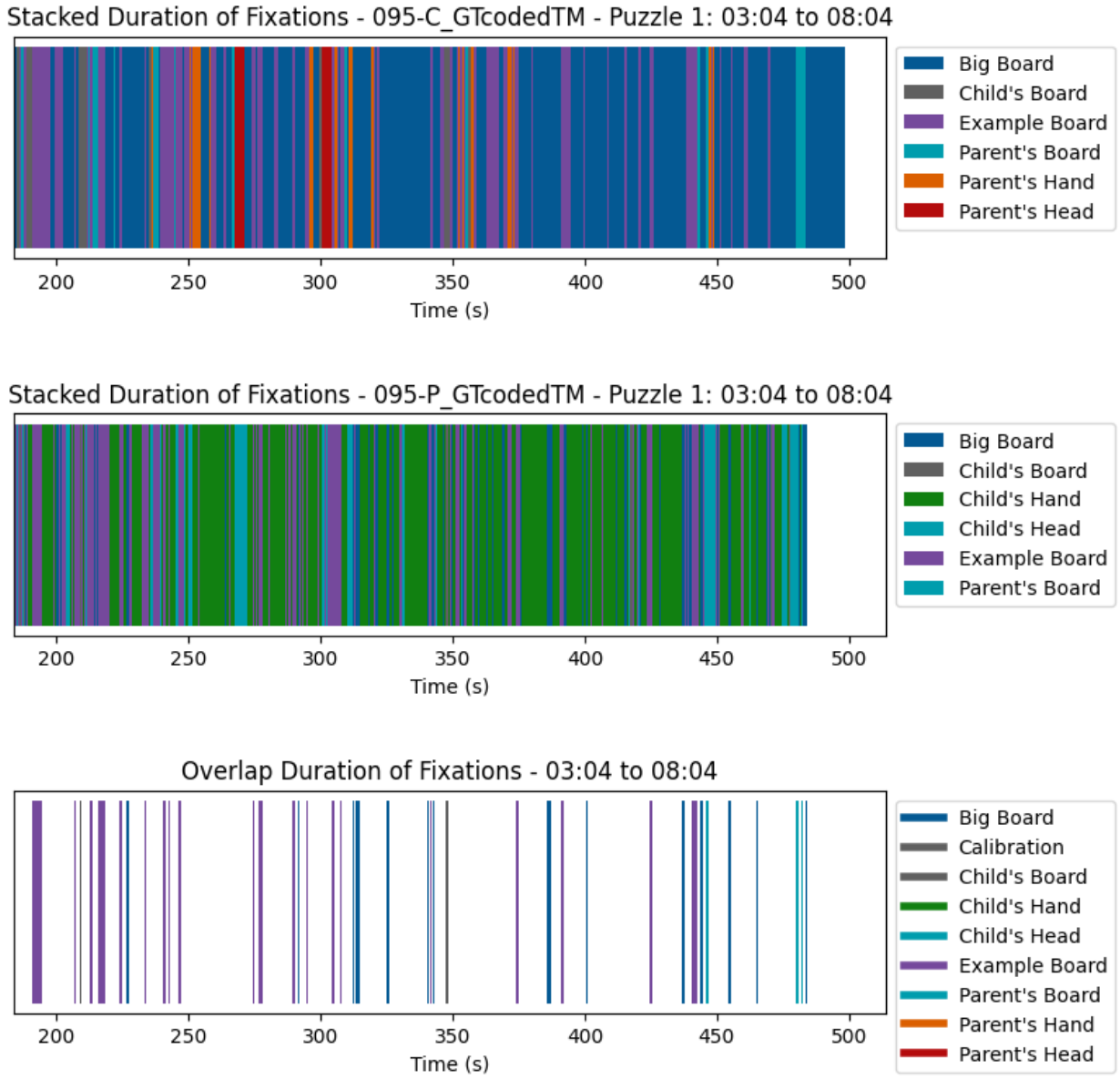
Eye-Tracking Visualization of Dyad 094 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B23.1

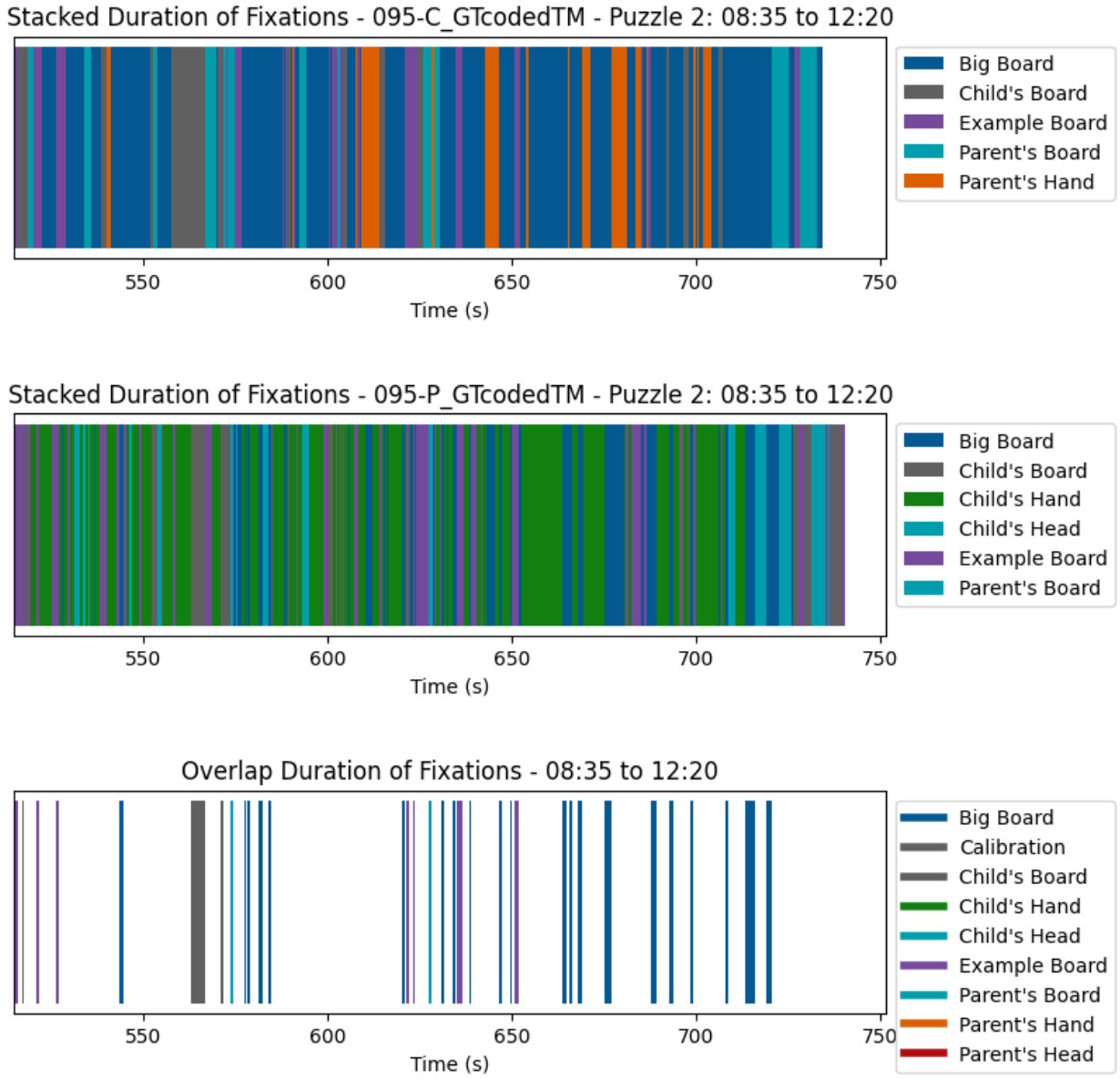
Eye-Tracking Visualization of Dyad 095 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B23.2

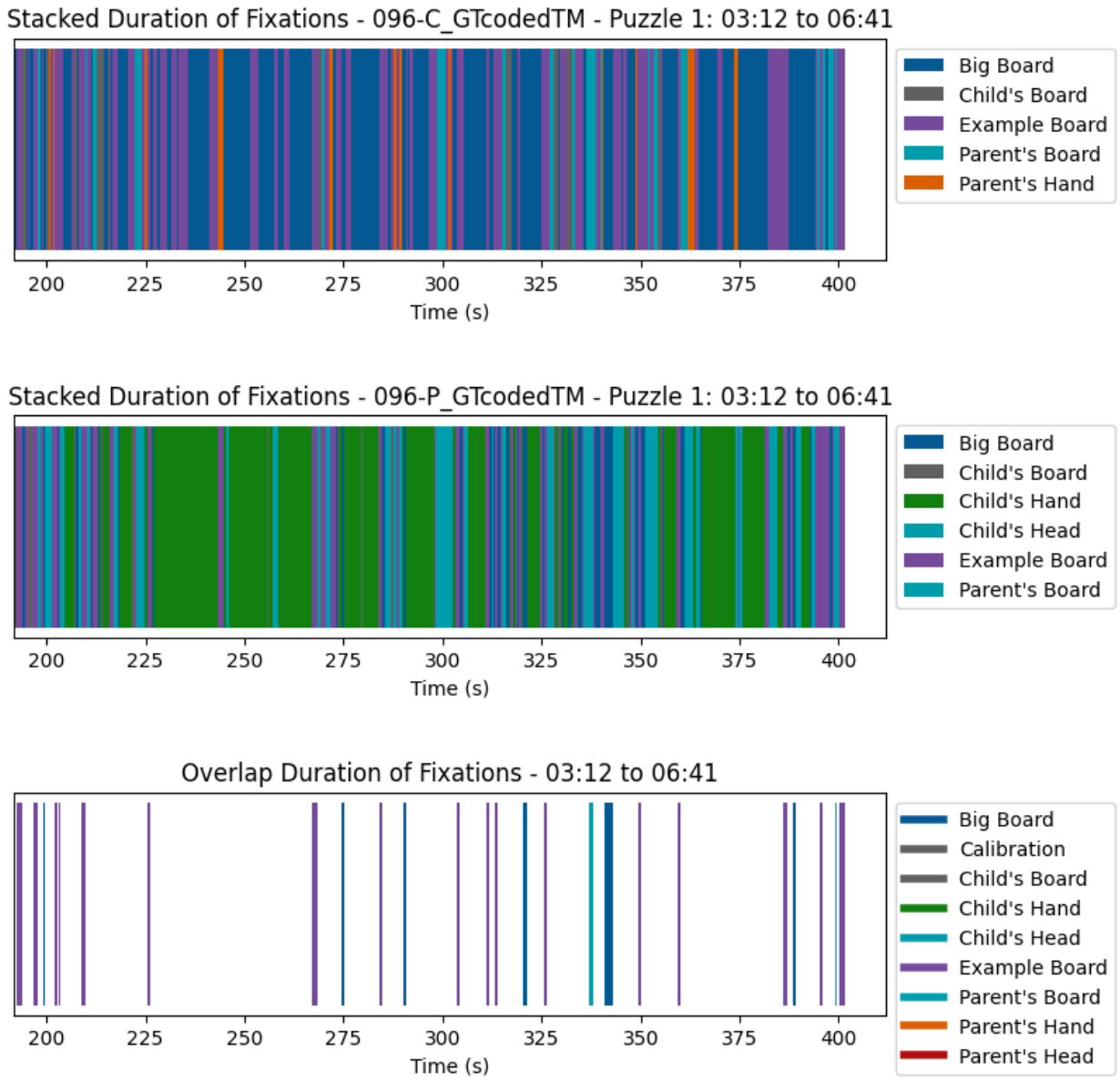
Eye-Tracking Visualization of Dyad 095 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B24.1

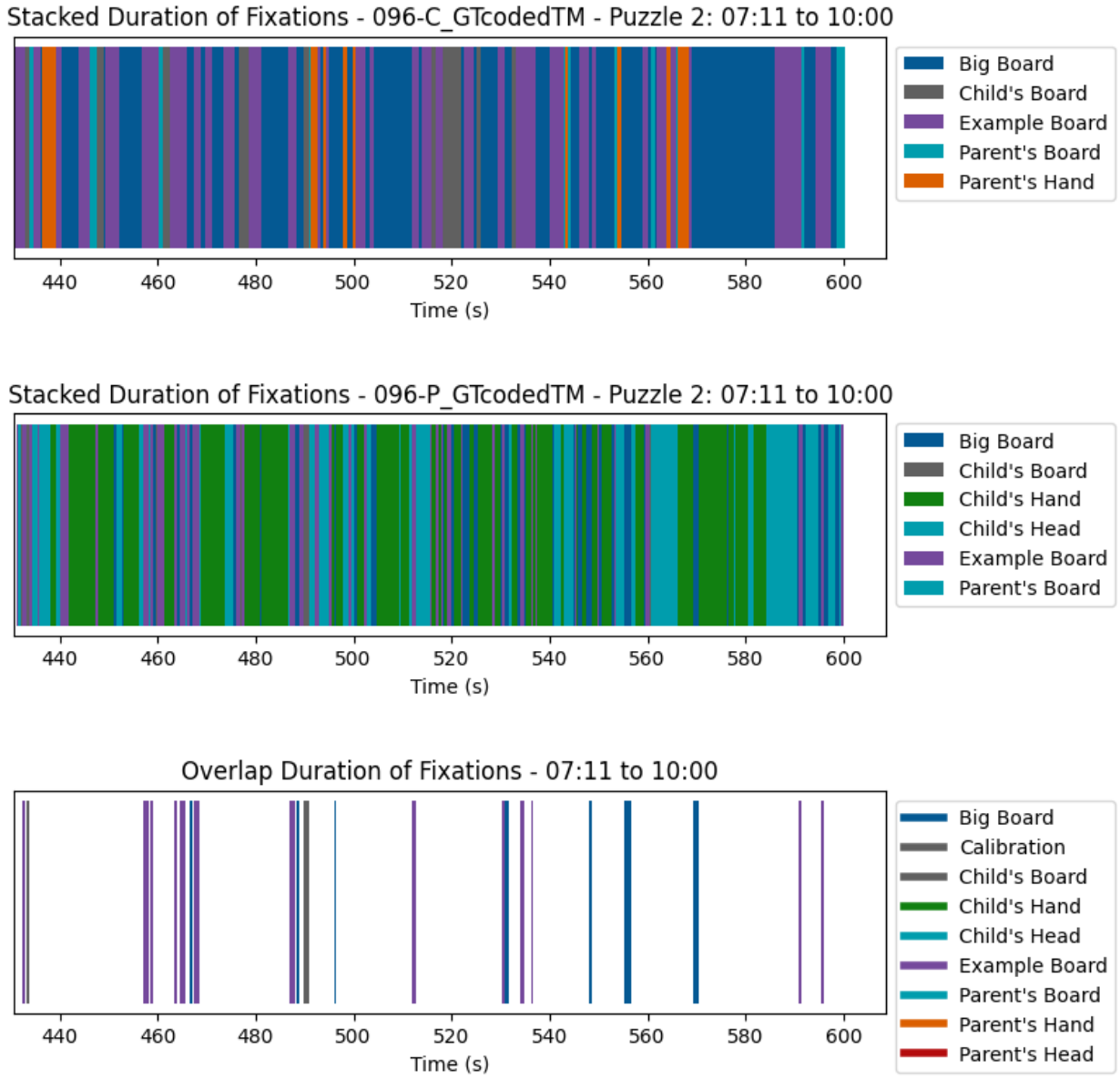
Eye-Tracking Visualization of Dyad 096 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B24.2

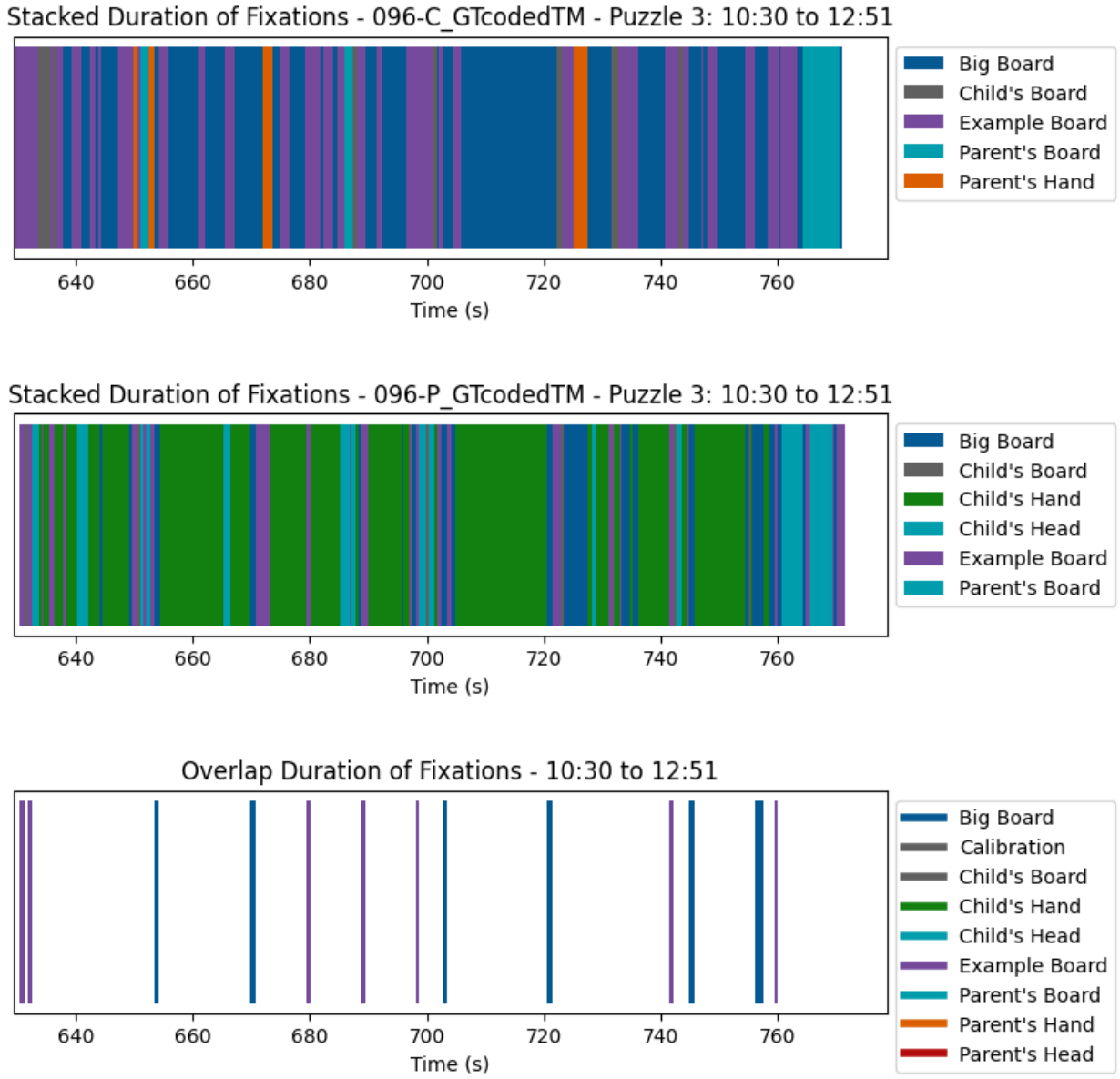
Eye-Tracking Visualization of Dyad 096 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B24.3

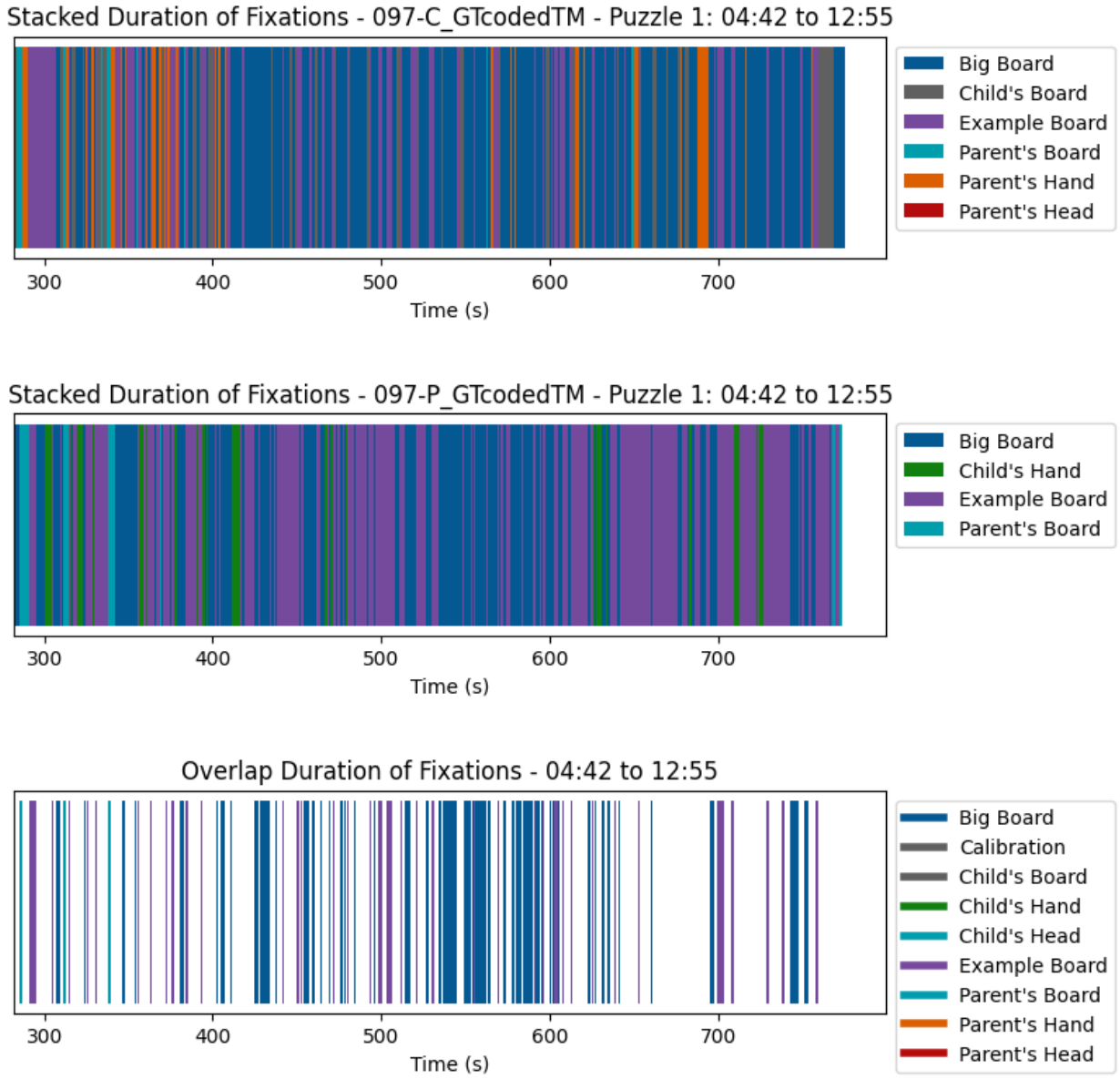
Eye-Tracking Visualization of Dyad 096 Puzzle 3



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B25.1

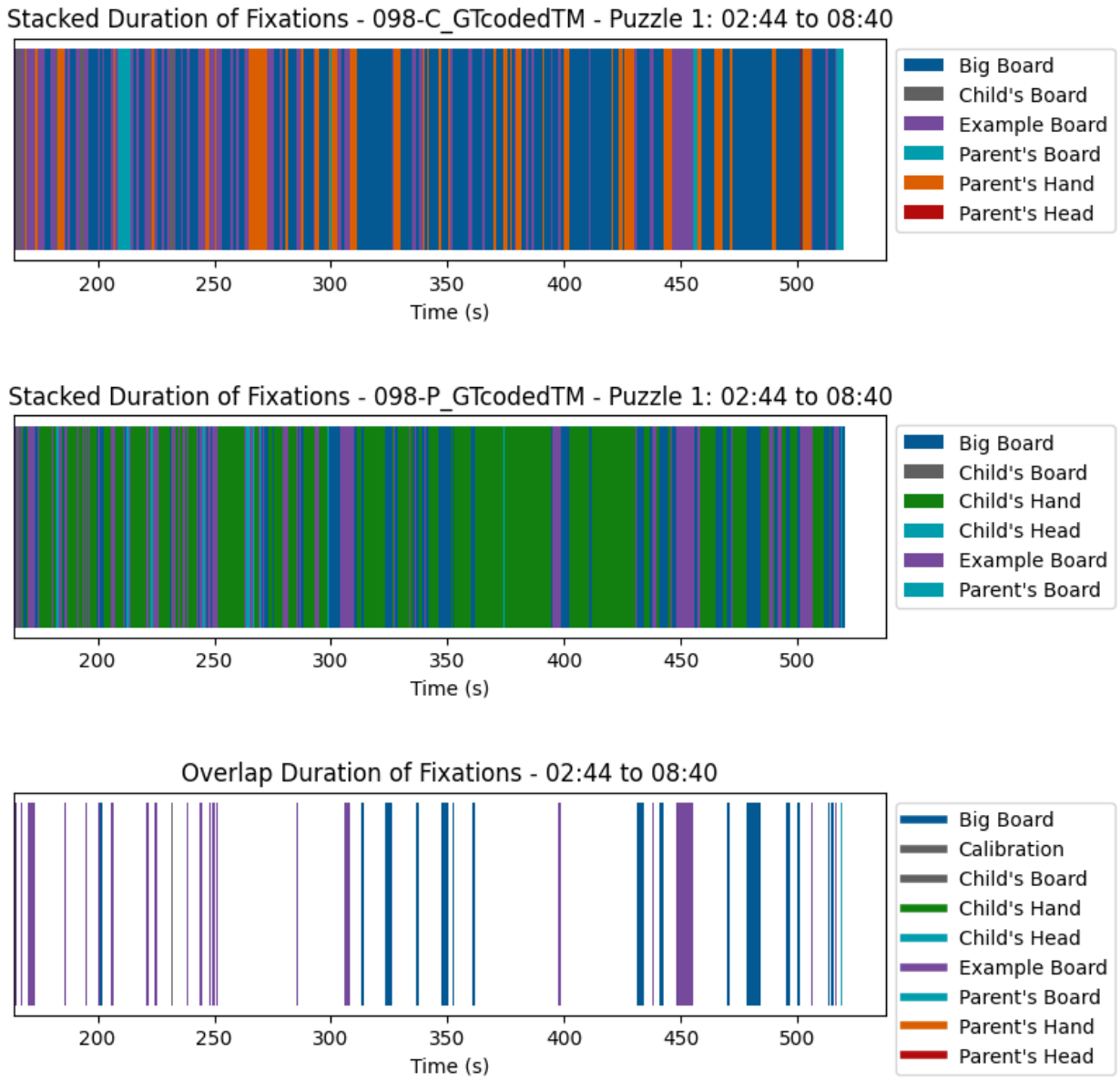
Eye-Tracking Visualization of Dyad 097 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B26.1

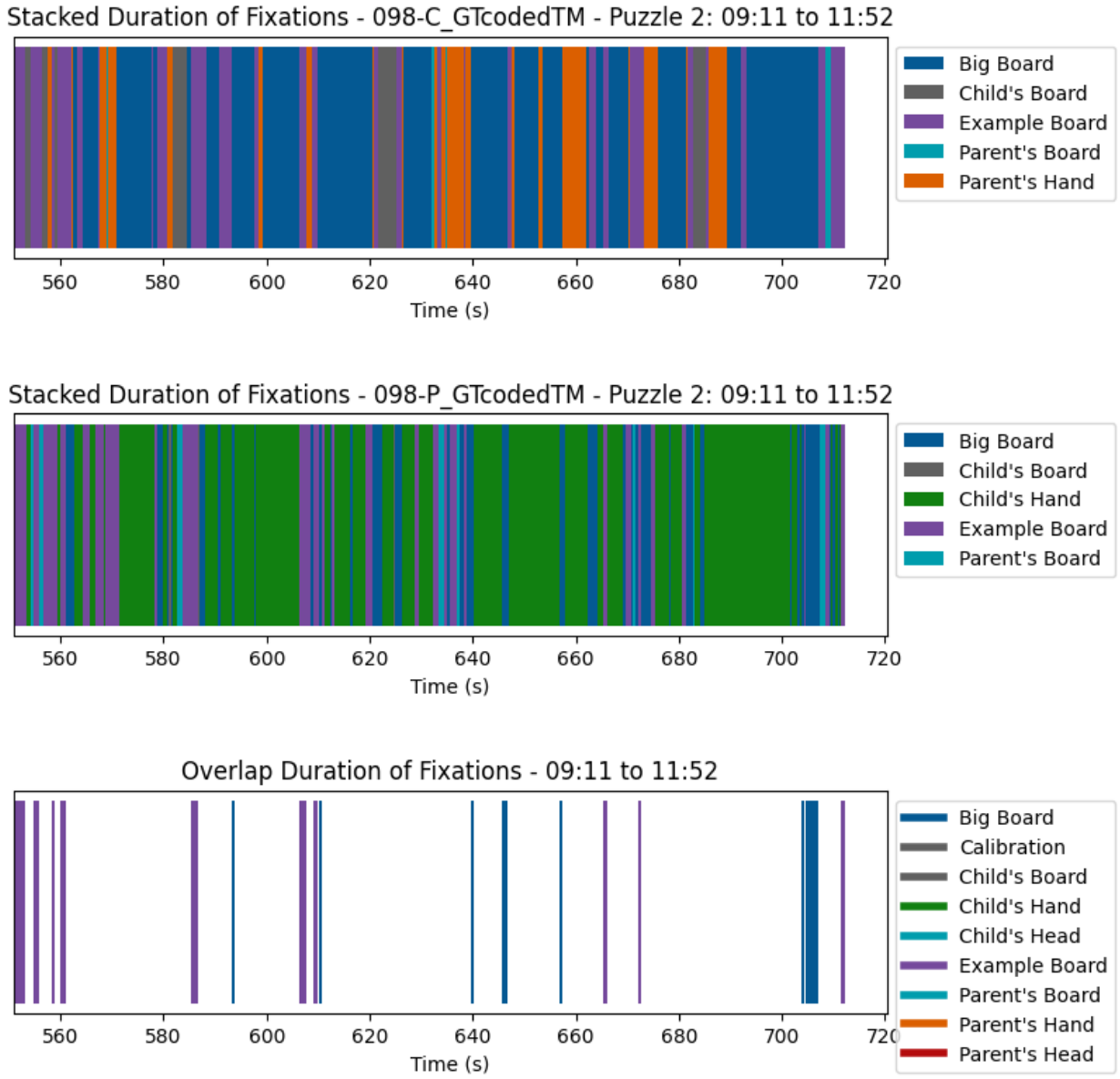
Eye-Tracking Visualization of Dyad 098 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B26.2

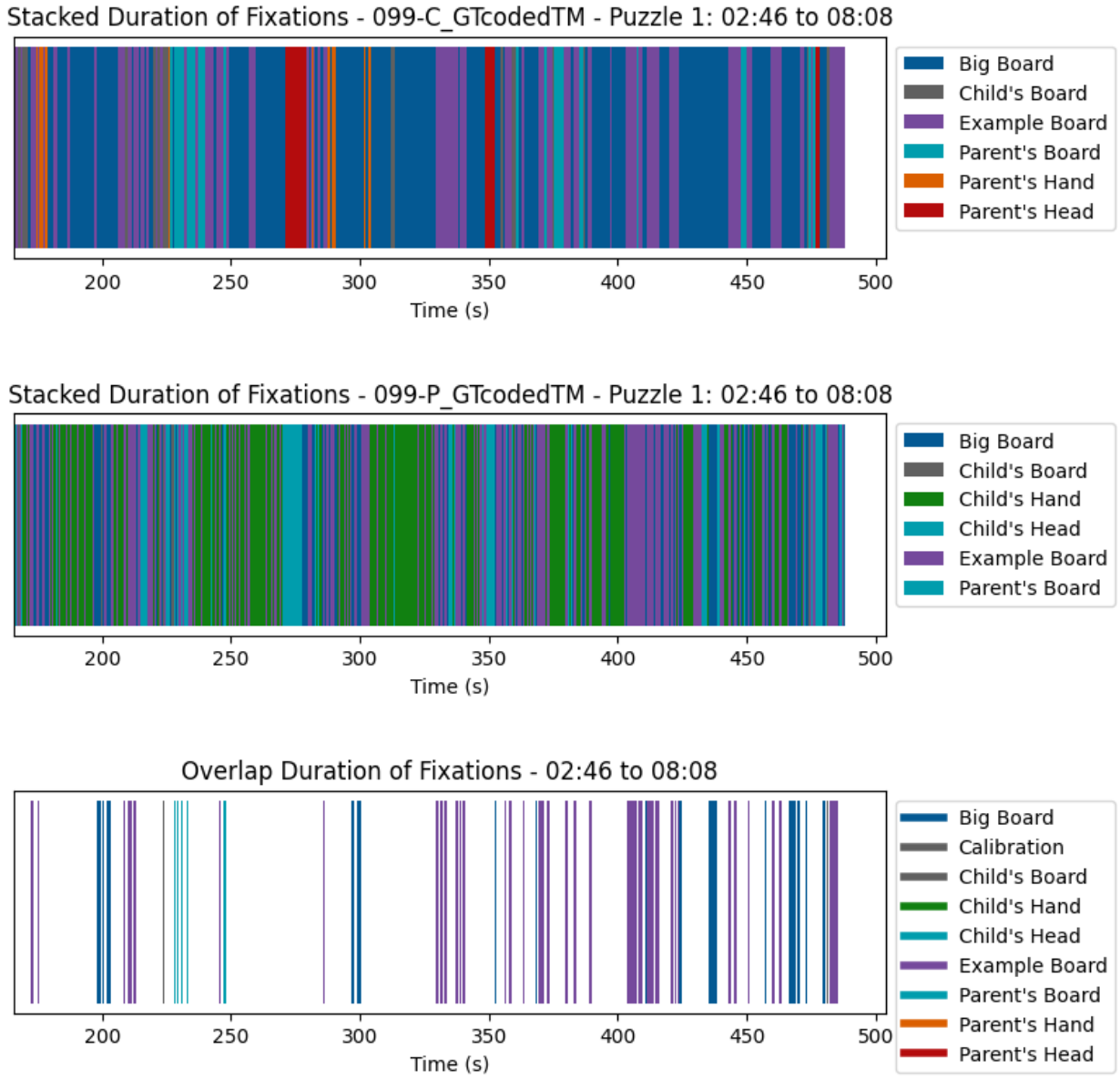
Eye-Tracking Visualization of Dyad 098 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B27.1

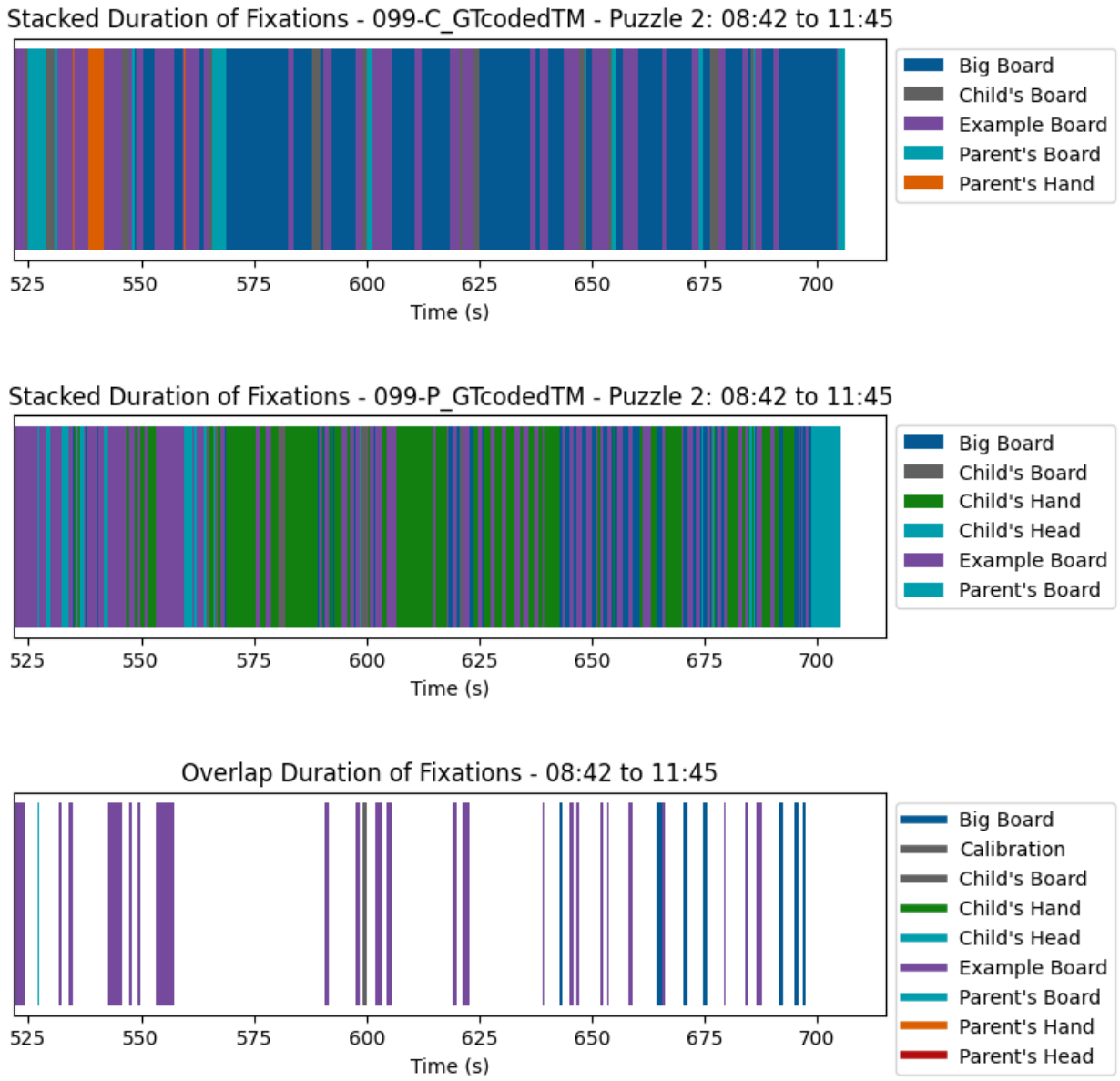
Eye-Tracking Visualization of Dyad 099 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B27.2

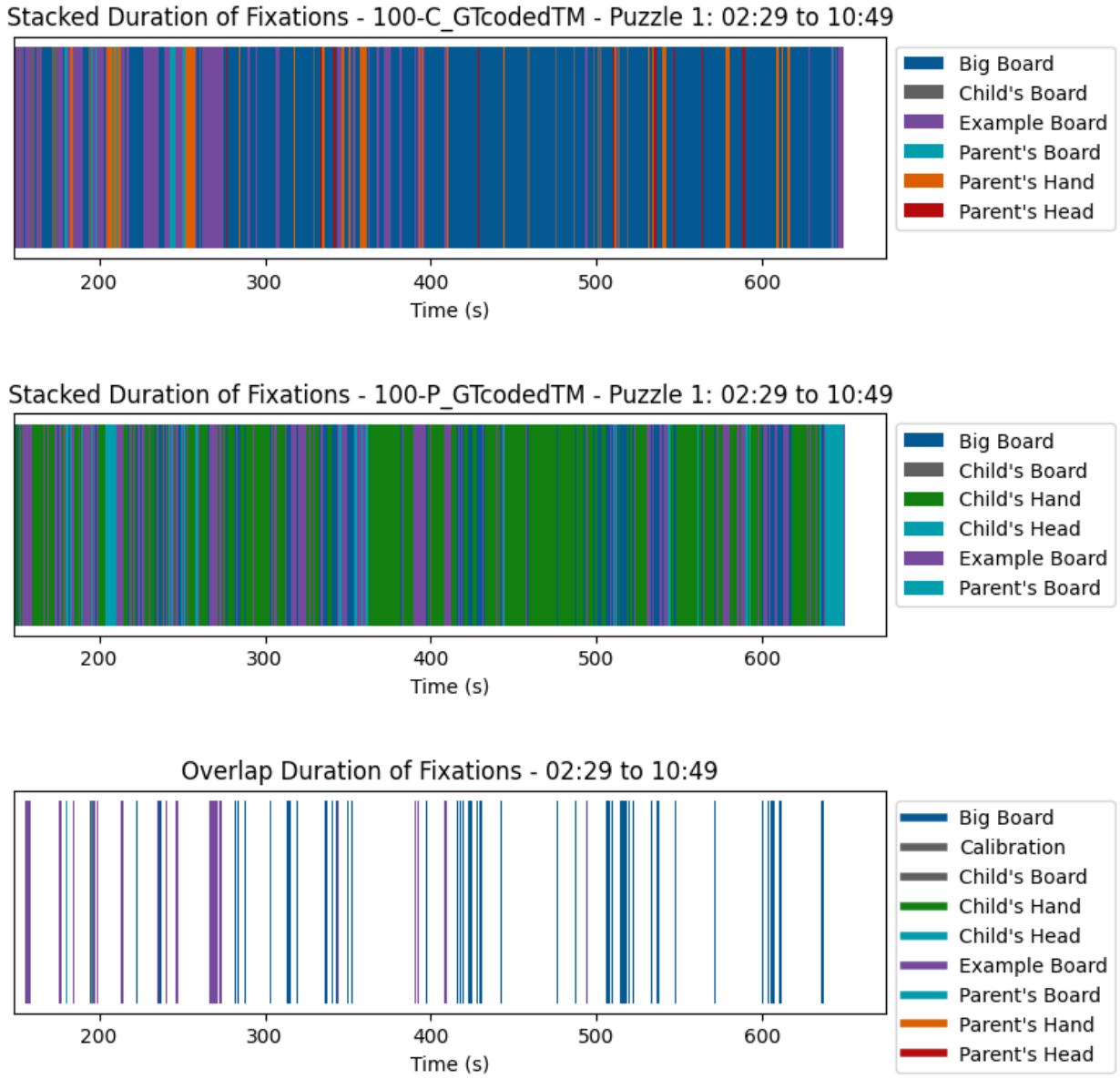
Eye-Tracking Visualization of Dyad 099 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B28.1

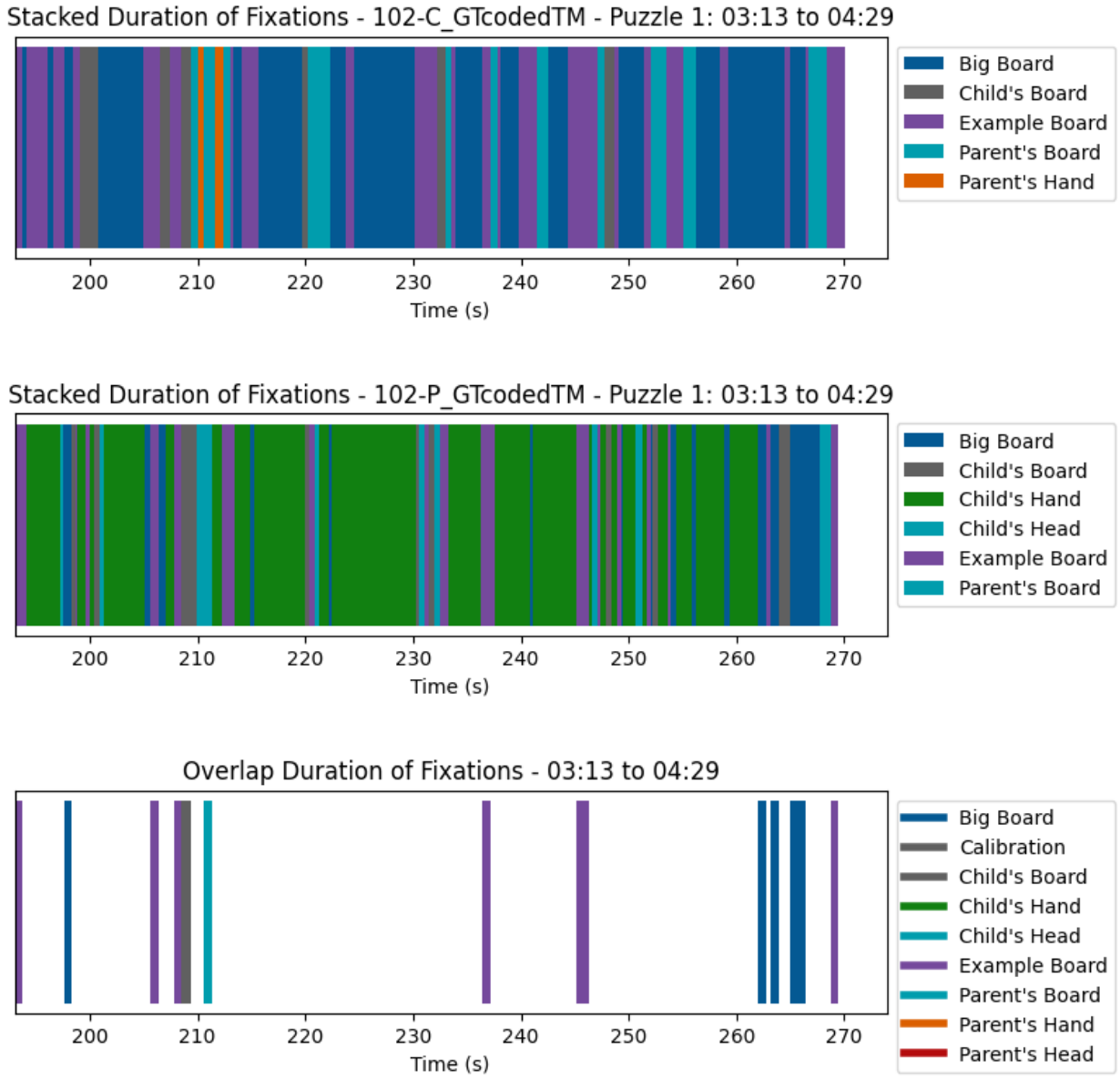
Eye-Tracking Visualization of Dyad 100 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B29.1

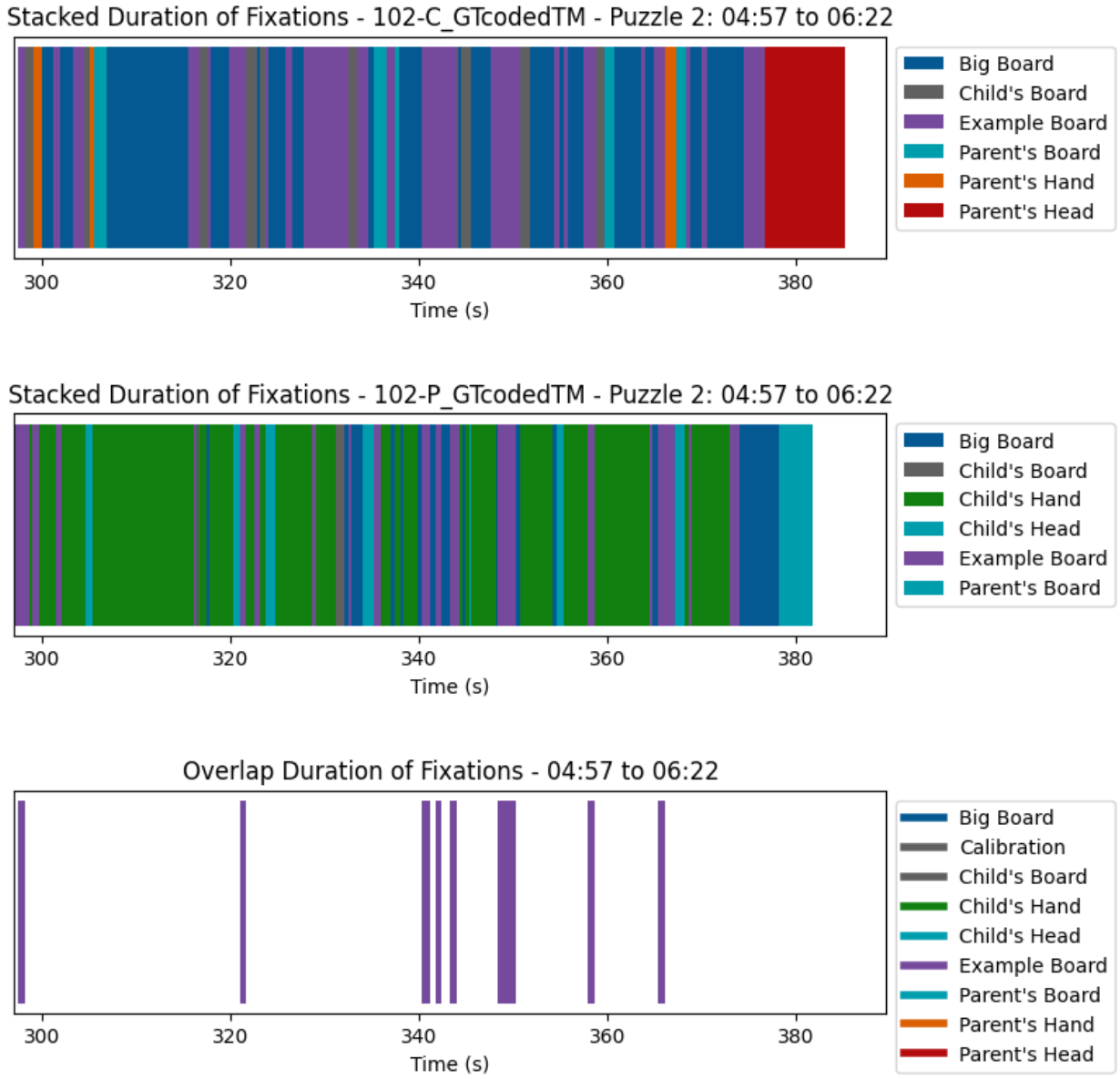
Eye-Tracking Visualization of Dyad 102 Puzzle 1



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B29.2

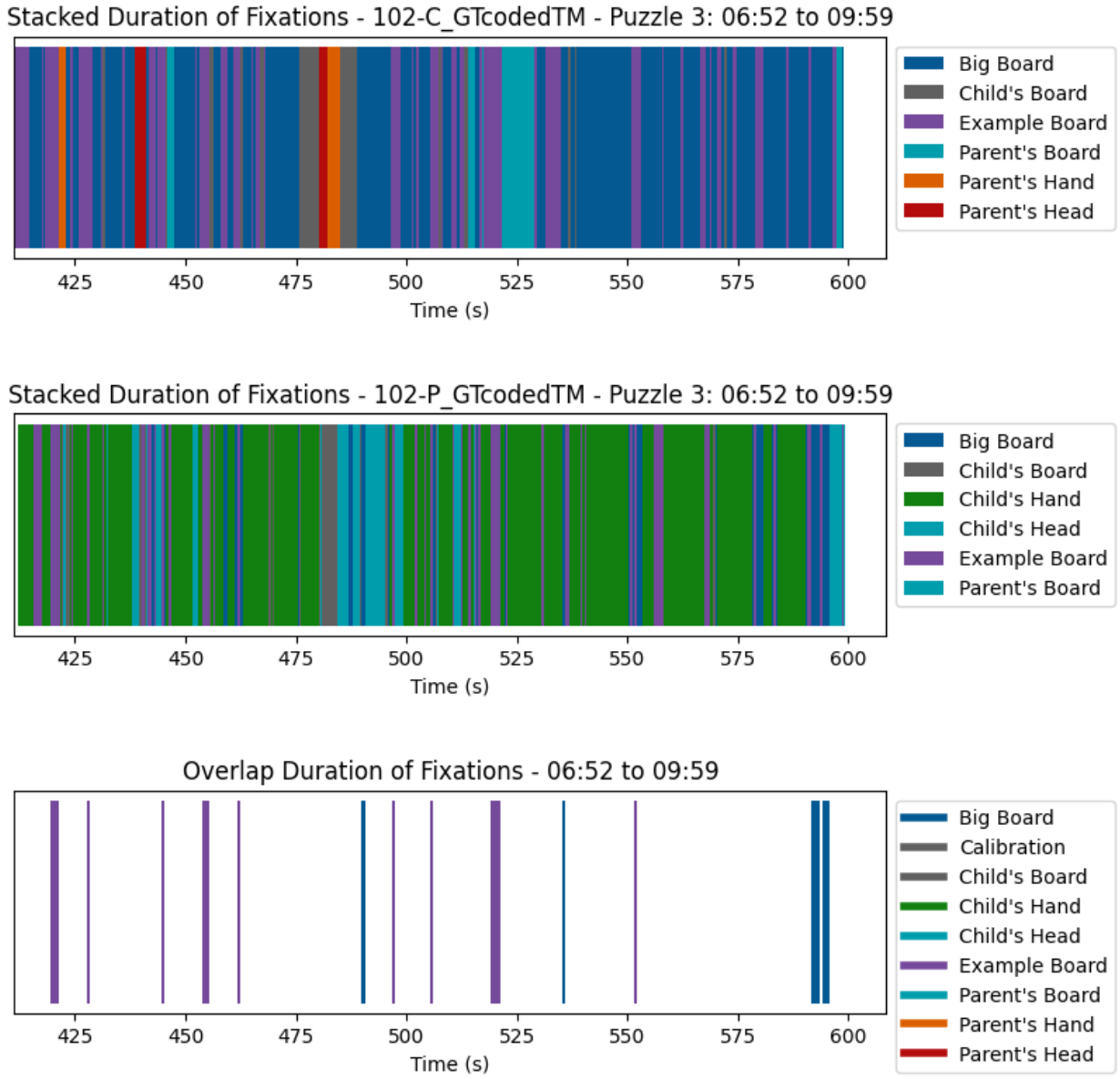
Eye-Tracking Visualization of Dyad 102 Puzzle 2



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.

Figure B29.3

Eye-Tracking Visualization of Dyad 102 Puzzle 3



Note. The top panel shows the child's fixations, the middle panel shows the parent's fixations, and the bottom panel shows the overlap fixations between the two.